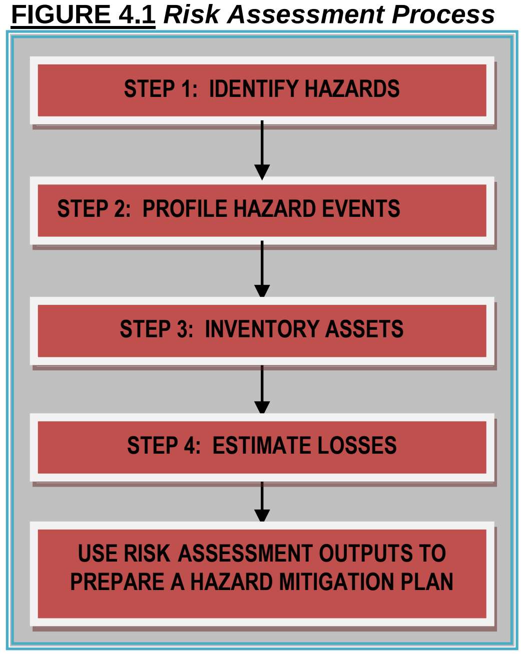
This section is organized around the risk assessment process that includes the following eight subsections:

- 4.1 Introduction and Methodology
- 4.2.IFR Requirements for Risk Assessment
- 4.3 Hazard Identification
- 4.4 Hazard Profile
- 4.5 Inventory of Assets
- 4.6 Vulnerability Assessment
- 4.7 Loss Estimates
- 4.8 Loss Estimation Summary and Hazard Ranking

4.1 INTRODUCTION & METHODOLOGY

The risk assessment methodology utilized in this Plan Update is the same as was utilized in the 2008 Plan. It is consistent with the process and steps presented in FEMA Publication 386-2, “State and Local Mitigation Planning How-To Guide, Understanding Your Risks—Identifying Hazards and Estimating Losses” (FEMA 2001) and utilizes a risk assessment methodology similar to HAZUS-MH. Figure 4.1 shows the four major steps that comprise the risk assessment process: Hazard Identification, Hazard Profiling, Vulnerability Assessment, and Loss Estimation.

FIGURE 4.1 ***Risk Assessment Process***



Step 1 – Hazard Identification

The hazard identification was compiled by investigating the various natural hazard occurrences within the Territory.

Because it is assumed that hazards that occurred in the US Virgin Islands in the past may be experienced in the future, the hazard identification process for this Plan Update included extensive discussions with VITEMA, its Hazard Mitigation Steering Committee, island Hazard Mitigation Committees and the general public.

Discussions with these groups focused on the identification of hazards for this Plan Update. Information of past hazards was obtained from historical hazard assessment documents, and hazard specific plans and reports developed by experts over the past two decades.

Step 2 – Hazard Profiling

This step involved determining the extent where possible (i.e. maps), the frequency or probability of future events, their severity, and factors that may affect their severity. Each hazard type has unique characteristics that can impact the Territory in different ways. At the hazard identification phase, several important natural hazards that could affect the US Virgin Islands were considered. The following natural hazards have been documented for the US Virgin Islands and have been assessed as risks for the purpose of this Plan Update. They are listed in the order that they will be discussed in the Plan Update:

- Drought,
- Earthquake,
- Riverine Flooding,
- Coastal Flooding and Erosion,
- Hurricane Winds,
- Rain-Induced Landslide,
- Tsunami, and
- Wildfire

The results of the hazard identification process and discussions reveal that the hazards listed above warrant a vulnerability assessment. It is important to note, however, that the consultant team formally indicated to VITEMA, that there was a concern about the availability of data concerning the mapping (extent) and historic data required to understand the frequency and vulnerability of several of the identified hazards, specifically rain-induced landslide, drought and wildfire.

It is necessary to note that several of these hazards were identified as concerns during the 2011 plan update and mitigation actions were included in the 2011 Plan and 2014 Plan to collect information concerning the location, frequency and history of these events in the Territory. No data has been collected for use in this Plan Update and that data gap will limit the ability to fully profile these hazards – i.e. catalog of events from which to ascertain their frequency of occurrence and/or estimate the magnitude of historical events, let alone to accurately estimate vulnerability and losses (i.e. future impacts).

It is also necessary to note that each hazard model or map that was developed for the 2011 Plan update, with the exception of the Tsunami hazard. The potential impact of climate variability on natural hazards identified in the plan has been discussed qualitatively in the description of the hazards as well as the deficiencies in addressing the impacts of climate change in a more quantitative manner. As such, actions have been added to the Mitigation Strategy (Section 5) of this Plan Update.

Step 3 – Inventory of Assets
The inventory of assets quantifies what can be lost when a hazard occurs. Specifically, the people, places, and property that could be injured, damaged, or destroyed are quantified. The following data was collected and calculations were made:

- Estimate or count the total number of buildings, value of buildings, and population in the Territory.
- Determine the proportion of buildings, the value of buildings, and the population in located in hazard prone areas, and
- Calculate the proportion of assets located in hazard areas.

In order to understand that vulnerability of people, buildings and infrastructure to natural hazards, a comprehensive inventory of assets was conducted. Inventory data was classified into a number of asset categories, including population, general building stock, and infrastructure.

Population.
2010 U.S. Census information was updated using projected annual population growth rates for the Territory. A series of calculations were performed to identify the number of people less than 18 years of age and the number of people over 65 years of age. These two demographic subgroups help define the territory's social vulnerability as these two population groups are the most likely to need assistance during and/or after a hazard event.

General Building Stock.
The Virgin Islands Tax Assessors Office (Division of the Office of the Lt. Governor) provided the consultant project team an assessment of the Tax Assessment database in 2014 to assist in the classification of the general building stock. The 2014 database was updated to categorize the built environment into two general occupancy categories: commercial and residential. Detailed below are the procedures used to identify the number of buildings and to estimate the exposure values of the general building stock (replacement and content values).

1. Tax lot or parcel information was aggregated for each estate on each island to identify the number of buildings per occupancy class, per estate. Analysis was limited to commercial and residential type buildings. Data limitations within the tax assessment database precluded the consideration of other occupancy classes, i.e., industrial, government, agricultural, and religious institutions.

2. A matrix was developed to relate the number of building and occupancy classes to specific building types, showing the distribution of model building types throughout each island. Distribution information was compiled to determine the number of building types per specific occupancy class. Collected data was aggregated at the estate level for each island.

3. An average replacement cost was developed for each building type. Replacement costs were based on average construction costs per square foot, reflecting labor and material costs for each island. For each occupancy class, content values were determined as a percent of the replacement

costs (i.e. multiply building replacement costs by content cost percentage to calculate content value).

4. This analysis facilitated a determination of the number of buildings per occupancy class and an aggregate estimate per estate of exposure costs (i.e. replacement value added content value). To enable an island by island comparison, the number of buildings and aggregate replacement and content values of each island were delineated to identify total exposure values for general building stock.

The data utilized in this Plan Update was aggregated from values in the Tax Assessor building stock data and contains estimates of residential and commercial values based on price indexes for housing and construction costs. Annual data sets were derived from publicly available data from the Bureau of Economic Analysis (BEA). The value of structures identified as residential and commercial purposes in this Plan Update are considered to be of “fair market value” for the US Virgin Islands.

Critical Facilities and Infrastructure.
A detailed list of critical facilities and infrastructure was developed by VITEMA with the input from the Hazard Mitigation Steering Committee. The list was based on critical facilities included in the 2011 Plan, the Critical Facility Infrastructure Plan and from information collected from Department of Property and Procurement. Detailed procedures used to update exposure values of critical facilities (replacement and content values) are provided below:

1. VITEMA provided the consultant team with a current listing of critical facilities and infrastructure. It was revealed that the listing was the same as was utilized in the 2011 Plan Update. Therefore, there were not any new critical facilities added to the listing nor were there any site visits undertaken in the 2014 Plan Update. Site visits were not necessary as the general structural characteristics and general conditions of each critical facility identified by VITEMA did not change significantly since the last Plan Update.

2. Facilities/structures were categorized by structural characteristics relevant to the prominent hazards addressed in the vulnerability assessment. The approximate square footage for each facility/structure or group of buildings.

3. Replacement and content values for facilities for the 2011 Plan were provided by the VI Department of Property and Procurement. An evaluation of this data revealed that approximate building areas and construction costs (i.e. exposure) were overstated. Therefore, this Update Plan relied on construction price indices and inflation factors derived from the U.S. Department of Commerce, Bureau of Economic Analysis to update replacement estimates for critical facility classes for this plan update.

The final step of the inventory process is a **vulnerability assessment**, which facilitates an understanding of the proportion of buildings, the value of buildings, and the population that is located in hazard areas. The results of the hazard identification and profile were used to understand characteristics of hazards (i.e. wind speed, flood depth, etc.) in order to assess the vulnerability parameters (specific damage and loss characteristics) of each asset identified. For instance, a wood frame building will have different damage and loss characteristics for a hurricane than a reinforced concrete structure. A hazard vulnerability assessment level (very low, low, medium, high, and very high) was assigned to each building type or facility to express the vulnerability for the general building stock (model building types) and critical facilities and infrastructure in qualitative terms. It is necessary to note that vulnerability estimates were not conducted for all hazards, especially drought, rain-induced landslides and wildfires. Instead, hazard overlays were performed to identify the number of buildings in hazard susceptibility zones identified on newly created maps for these hazards.

Step 4—Loss Estimation

Based on the vulnerability assessment for the general building stock, damage functions were developed to translate the hazard intensity data (given in terms of wind speed, ground shaking, depth of flooding, etc.) into its respective economic loss potential. In its simplest form, a damage function estimates the potential economic damage (e.g., cost to repair/replace the damaged components) of a building or group of buildings to a specified level of hazard intensity. For this study, damage functions were developed based on standard damage ratios obtained from HAZUS^{MH} for hurricane wind, earthquake and flooding, various published reports, expert opinion and other propriety information. Data limitations did not allow for the development of damage functions or the newly identified hazards: drought, rain-induced landslide and wildfire. The vulnerability assessment only provides a rough estimate of the built environment that is exposed to these hazards and does not allow for a characterization of how a structure or group of structures would perform at a certain level of hazard intensity.

Below are procedures for a prototypical estate in the US Virgin Islands:

1. Hazard maps (location) and hazard profile information (intensity) were used to identify the natural hazard affecting a particular area. Based on the intersection of hazard areas, each estate was assigned a particular hazard intensity level (i.e. hurricane wind speed).

2. Exposure to a specific hazard (i.e. number of buildings, % percentage of total buildings, and value) was determined for identified buildings (general building stock and critical facilities).

3. A qualitative vulnerability level was assigned to each model building type to understand the vulnerability of buildings. This is expressed as a percentage of damage based on a specific hazard level.

4. Qualitative vulnerability levels were related to specific loss estimation tables to determine a specific percentage of damage to a structure (i.e. replacement and content value).

5. To calculate losses, the expected percentage of damage was multiplied by the structure replacement cost and content value.

The loss estimation process provides the US Virgin Islands with a relative ranking of risk to general building stock and critical facilities and infrastructure from various hazards.

Loss estimates associated with drought, wildfire and rain-induced landslides were not analyzed using a risk assessment methodology based on the same principals as described above. Instead, available historical data for each hazard are used and statistical evaluations are performed using manual calculations. The general steps used in this methodology include: compilation of data from national and local sources; verification of data using statistical analysis; determine the frequency of hazard occurrence; and, estimate damages associated with a specific hazard occurrence.

It is important to note that loss estimates in this risk assessment used the best available data and methodologies, but should still be considered approximate. These estimates should be used to understand relative risk from hazards and potential losses and are not intended to be predictive of precise results. Uncertainties are inherent in any loss estimation methodology arising in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from approximations and simplifications that are necessary for a comprehensive analysis (e.g., incomplete or outdated inventory, demographic or economic parameter data).

4.2 IFR REQUIREMENTS FOR RISK ASSESSMENT

4.2.1 IFR Requirements for Hazard Identification and Profiles

§201.4(c)(2) of the IFR states that "[the State plan must include a risk assessment] that provides the factual basis for activities proposed in the strategy portion of the mitigation plan. Statewide risk assessments must characterize and analyze natural hazards and risks to provide a statewide overview. This overview will allow the State to compare potential losses throughout the State and to determine their priorities for implementing mitigation measures under the strategy, and to prioritize jurisdictions for receiving technical and financial support in developing more detailed local risk and vulnerability assessments."

The IFR includes two specific requirements for the identification and profiling of natural hazards:

- **Hazard Identification** per **Requirement §201.4(c)(2)(i): "**[The State risk assessment shall include an] overview of the type … of all natural hazards that can affect the State …."
- **Hazard Profiles** per **Requirement §201.4(c)(2)(i**): "[The State risk assessment shall include an overview of the] location of all natural hazards that can affect the State, including information on previous occurrences of hazard events, as well as the probability of future hazard events, using maps where appropriate …"

4.2.2 IFR Requirements for Vulnerability Assessment and Loss Estimation

The IFR includes two specific requirements regarding vulnerability assessments and loss estimates:

- **Vulnerability Assessment** per **Requirement §201.4(c)(2)(ii): "**[The State risk assessment shall include an] overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments as well as the State risk assessment. The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events. State-owned critical or operated facilities located in the identified hazard areas shall also be addressed."

- **Estimated Losses** per **Requirement §201.4(c)(2)(iii): "**[The State risk assessment shall include an] overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. The State shall estimate the potential dollar losses to State owned or operated buildings, infrastructure and critical facilities located in the identified hazard areas."

US Virgin Islands local risk assessments were not available. In order to provide risk comparisons among the islands, the Plan Consultant performed, for each island, local risk assessments that meet the IFR **Requirement §201.6(c)(2)** for local mitigation plans. These local risk assessments, while not required by the State IFR guidelines, provide information valuable to the mitigation process.

4.3 HAZARD IDENTIFICATION

Since the completion of the 2011 Plan there have not been any new Presidential Disaster Declarations in the US Virgin Islands. As a result, the Territory has not suffered significant loss of property from natural hazards. Since 1995, the US Virgin Islands has received eleven presidential disaster declarations. As shown in Table 4.1, the main sources of damages in recent years have been hurricanes and flooding.

Table 4.1 Presidential Disaster Declarations in the US Virgin Islands, 1994 – 2010

Year	Date	Declaration / Disaster Type
2010	11/24	Severe Storms, Flooding, Rockslides, and Mudslides associated with Tropical Storm Tomas
2010	11/05	Severe Storms, Flooding, Mudslides, and Landslides associated with Tropical Storm Otto
2010	09/28	Hurricane Earl
2008	1/29	Hurricane Omar
2004	10/07	Major Disaster / Tropical Storm (Jeanne)
2003	12/09	Major Disaster / Flooding
1999	11/23	Major Disaster / Hurricane (Lenny)
1999	11/18	Emergency / Hurricane (Lenny)
1998	09/24	Major Disaster / Hurricane (Georges)
1996	07/10	Major Disaster / Hurricane (Hortense)
1995	09/16	Major Disaster / Hurricane (Marilyn)

These hazards have challenged the US Virgin Islands to develop ways to reduce future damages. This subsection describes the process used to identify those hazards addressed in detail in the risk assessment of this Plan Update.

The process included reviewing and identifying a list of natural hazards. The review and evaluation of the hazards included those identified in the 2011 Plan Update. There were not any new additions It is important to note that the Tsunami section in this Plan Update was updated due to new hazard mapping data. The list of hazards addressed in this Plan Update include:

- Drought,
- Earthquake,
- Riverine Flooding,
- Coastal Flooding and Erosion,
- Hurricane Winds,
- Rain-Induced Landslide,
- Tsunami, and
- Wildfire

Each hazard was discussed in detail during the Hazard Mitigation Evaluation Committee and island specific Hazard Mitigation Committee meetings, in addition to summarizing the hazards evaluated and risk assessment process to the general public during public informational workshops. Citizens were given a chance to review this listing and express concerns about hazards on their respective islands.

Citizens on St. John expressed concerns about hurricanes, earthquakes and landslides, while residents on St. Thomas and St. Croix spoke about hurricanes, earthquakes and a greater concern about riverine flooding.

Hazard identification was conducted during a series of steering committee meetings and public informational meetings. The result of this community input and pursuant discussions with VITEMA allow for an evaluation of each of the hazards with criteria that was set forth in the 2014 Plan Update. The evaluation criteria included the following five major benchmarks:

- Ability to describe the hazard,
- Ability to describe the nature of the hazard in USVI,
- Ability to identify the location and map the extent of the hazard,
- Ability to document previous occurrences and frequency of the hazard, and
- Ability to quantify losses for the hazard

The participants at all of the public informational meetings contributed through a lively discussion of both the reasons for inclusion and conversely the reasons for exclusion of hazards that should be addressed in this Plan Update. The decision for the inclusion for the following hazards was made by the Hazard Mitigation Steering Committee. This was indicated to the consultant team that all hazards included in the 2011 Plan are still valid and are of concern to VITEMA.

TABLE 4.2 ***Hazard Identification Evaluation Matrix, 1994 – 2010***

Hazard/Criteria[1]	Ability to describe the hazard	Ability to describe the nature of the hazard in USVI	Ability to identify the location and map the extent of the hazard	Ability to document previous occurrences and frequency of the hazard	Ability to quantify losses for the hazard.
Drought	3	3	2	1	1
Earthquake	4	4	4	4	4
Riverine Flooding	4	4	4	4	4
Coastal Flooding and Erosion	4	4	4	4	4
Hurricane Winds	4	4	1	4	4
Rain-induced Landslide	3	3	3	1	2
Tsunami	4	4	4	4	4
Wildfire	2	2	2	1	1

Based on the results, the consensus was to endeavor to undertake an assessment of all of the identified hazards. The Hazard Mitigation Steering Committee and island Hazard Mitigation Committees felt that the several key hazards posed the highest threat to the Territory and demanded attention. These hazards are Hurricane, Earthquake, Flooding and Landslides.

Discussion focused on the fact that there were not sufficient credible and historic data for drought, rain-induced landslides and wildfire hazards to address these hazards in a thorough manner during the last Plan Update. In this regard, the Territory should include specific actions to collect more reliable information for these and other hazards. Actions to collect more reliable information for these and other hazards were included in the 2011 Plan Update. The territory lacks sufficient resource to collect data for specific hazards and such recommendations to collect hazard specific data were removed from this Plan Update.

Nevertheless, VITEMA believes the Territory's position is justified as per key language included in the IFR, specifically the *IFR Requirement §201.4 (c)(2)(ii),* which states: **"***The State shall describe vulnerability in terms of the jurisdictions …* ***most vulnerable*** *to damage and loss associated with hazard events."* By identifying the most prevalent hazards, based on the experience of VITEMA, the Territory in effect is pursuing a meaningful evaluation of the *most vulnerable* areas on the three major Islands[2].

[1] Rating:

1 –low ability
2- moderate ability
3 –high ability
4 –very high ability

[2] *The US Virgin Islands Territorial Hazard Mitigation Plan, consistent with the intent of the Disaster Mitigation Act of 2000 (DMA 2000) is focused on natural hazards. The plan does not include consideration of any manmade hazards beyond the secondary effects of natural disasters on sites and facilities with technological, hazard materials or other manmade considerations.*

4.4 HAZARD PROFILE

4.4.1 HAZARDS AND CLIMATE VARIABILITY

The hazard profiles in this section provide a characterization of each of the hazards, along with a map that delineates the spatial extent of the hazard to identify hazard prone areas within the study area. Each hazard model or map that was developed for the 2011 Plan update has not changed as there was insufficient data to incorporate long-term meteorological data from the selected global climate change models and downscale them for the United States Virgin Islands, specifically for use in the update of hazard maps.

This, however, does not negate the fact that there is a potential impact of climate variability on natural hazards identified in the plan. The impact of climate change has been discussed qualitatively in the description of the hazards in this section of the plan, and deficiencies related to addressing the impacts of climate change in a more quantitative manner have been addressed in the Mitigation Strategy (Section 5) of this Plan Update.

The distinction of natural hazards must be made between those hazards that are potentially affected by climate change and those that are not. In general, all hazards that are of hydro-meteorological origin are potentially affected by climate change, while geo-hazards are generally not influenced by climate variability. The only exception is landslides, which can be caused by intense rainfall events. The figure provides a characterization of hazards identified for this study effort.

Natural hazard			Affected by Climate Change
Geo-hazards		Earthquake	No
Geo-hazards		Tsunami	No
Geo-hazards	Hydro-meteorological hazards	Landslide	Yes
	Hydro-meteorological hazards	Flood	Yes
	Hydro-meteorological hazards	Coastal Flooding	Yes
	Hydro-meteorological hazards	Drought	Yes
	Hydro-meteorological hazards	Hurricane	Yes
	Hydro-meteorological hazards	Wildfire	Yes

Source: Revised from Schmidt-Thomé 2005

It is necessary to note that projections simulated by global climate models are often simulated at space scales too coarse for direct use in impact studies at regional scale or smaller. Several organizations have employed techniques to derive the 21st century temperature and rainfall scenarios for the Caribbean from projections simulated by various global climate models, but there are to-date no models that are specific for use in the US Virgin Islands.

While acknowledging the above data and associated limitations, a set of reference projection ranges are used to allow for an understanding of the potential impacts of climate change in the Territory, which are summarized in the table below:

Hazard	Location	Climate Change Projected Impact	Potential Future Change in Hazard
Earthquake	St. Thomas, St. John, St. Croix	N/A	N/A
Tsunami	St. Thomas, St. John, St. Croix	N/A	N/A
Landslide	St. Thomas, St. John	Expected increase in intense precipitation events.	+
Flood	St. Thomas, St. John, St. Croix	Expected increase in intense precipitation events.	+
Coastal Flooding	St. Thomas, St. John, St. Croix	Projected rise in sea level will augment surge and wave heights to increase projected costal flood depths and extents.	+
Drought	St. Croix	Expected reduction in average rainfall which impact of drought; Average temperature increases reduce the water availability for drought and wildfire hazards.	+
Hurricane	St. Thomas, St. John, St. Croix	Percent increases in wind speed may be applied over the hurricane hazard to derive projected hurricane wind speeds taking into consideration variability	–
Wildfire	St. Croix	Expected reduction in average rainfall which impact of wildfire; Average temperature increases reduce the water availability for drought and wildfire hazards.	+
Legend: + increase in hazard intensity due to climate change; – decrease in hazard intensity due to climate change			

4.4.2 DROUGHT

Hazard Description

Drought is a normal part of virtually all climatic regimes, including areas with high or low average rainfall. Drought is the consequence of a natural reduction in the amount of precipitation expected over an extended period of time, usually a season or more in length.

Droughts can be classified as meteorological, hydrologic, agricultural, and socioeconomic. Table 4.3 below presents definitions for these types of droughts.

TABLE 4.3 *Drought Classification Definitions*

Term	Definition
Meteorological Drought	The degree of dryness or departure of actual precipitation from an expected average or normal amount based on monthly, seasonal, or annual time scales.
Hydrologic Drought	The effects of precipitation shortfalls on stream flow and reservoir, lake, and groundwater levels.
Agricultural Drought	Soil moisture deficiencies relative to water demands of plant life, usually cropland but can also include rangeland.
Socioeconomic Drought	The effect of demand for water exceeding supply as a result of a weather-related supply shortfall.
Source: *Multi-Hazard Identification and Risk Assessment: A Cornerstone of the National Mitigation Strategy*, FEMA	

Nature of the Hazard

In the U.S. Virgin Islands, adequate water supplies are critical for the wellbeing and economic security of the islands. Water resources or access to them are already limited and subject to competing demands (i.e. growing population and a growing tourist industry). The US Virgin Islands has extremely limited surface-water resources and limited ground-water resources, receives only moderate rainfall, much of which is lost to evaporation and surface run-off.

Therefore, droughts can exacerbate the problem of ensuring a sustainable yield of potable water. With no year-round streams and only limited ground water resources, 65% of drinking water supplies are provided by desalination (removing the salt from seawater). Groundwater provides 22% of the drinking water supply and the remaining 13% is from rooftop catchments.

Because the US Virgin Islands never has enough freshwater and a majority of the drinking water supplies are provided by desalination, it is already the most expensive publicly supplied water in the United States.

Any reductions in the amount or type of precipitation will only increase those costs.
http://www.usgcrp.gov/usgcrp/nacc/education/islands/islands-edu-3.htm

Droughts also increase the potential for wildfires, adversely affect farming, and can cause strains on already strained water resources throughout the territory.

Hazard Location, Extent and Distribution

Figure 4.2, 4.3, and 4.4 illustrate the geographic coverage of drought on all three islands. The entire Territory is susceptible to the effects of drought. There are, however, some useful distinctions between islands which should be noted:

- **St. Croix** – drought can have an impact in southern coastal areas on St. Croix, where historically large sections of land were allocated to agriculture, primarily dairy and livestock. Impacts included reduced productivity of rangeland and reduced milk production. Small scale agriculture can also be impacted. Production costs can increase owing to the cost of water supply, transport and/or transfer.

- **St. John** – Coral Bay is at risk to drought as precipitation shortfalls can impact small scale agriculture and impact residential developments because of increased costs for water supply, transport and/or transfer.

- **St. Thomas** – In terms of specific locations, the East End of the island is the most susceptible to the impact of droughts. Although, urban areas of Charlotte Amalie are not immune to drought due to increased costs for water supply and transfer.

Disaster History

The recorded history of droughts is very limited for the US Virgin Islands. There are scant references to droughts in historical reports. For instance, in 1733, when the islands were administered by the Danish, the islands were severely affected by drought, suffered an insect plague, and were affected by two hurricanes.

In the 1920's to 30's, St. Croix experienced a period of drought. During this time the U.S. Government assisted with the construction of Creque Dam (1923) to capture rain water. This program was expanded throughout the islands. Several reservoirs and catchment areas were constructed near the towns to collect rain water. Ponds were created for maintenance of livestock. Windmills were converted to cisterns and wells were sunk in former cane fields to fill water troughs.

The first Federal declaration in US Virgin Islands for drought was in June 8, 1964. Although the effects of this event are were not reported, it is listed on FEMA's website as an extreme event.

In recent years, droughts have been more frequent and severe. Minor shortfalls in rainfall have dramatically affected agriculture and have required water rationing. In 2002, the Virgin Islands Daily News reported that

East End of St. Croix was suffering a localized severe drought. According to local farmers this drought compares to the drought of the early 1970s. This event predicated the need for organized feeding programs and consequently had a major impact to cattle farmers. The National Weather Service reported that accumulated rainfall for St. Croix through 2002 was deficient. During the last seven months of that year, approximately 55 percent of normal rainfall was received.

According to the National Climate Data Center, there have been no new drought events reported in the Territory since 2002.

FIGURE 4.2 ***Drought Hazard Map, St. Thomas***

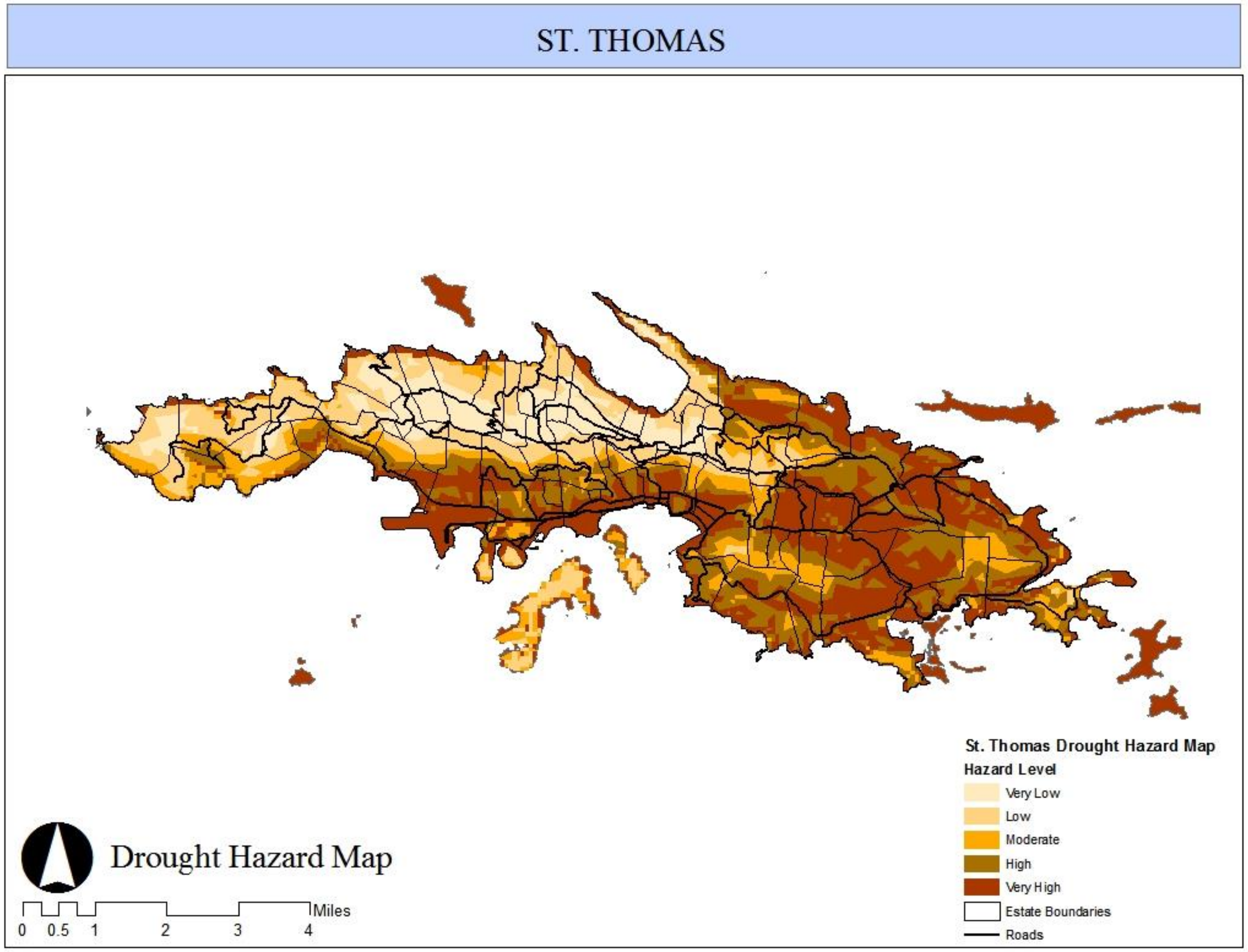


FIGURE 4.3 ***Drought Hazard Map, St. Croix***

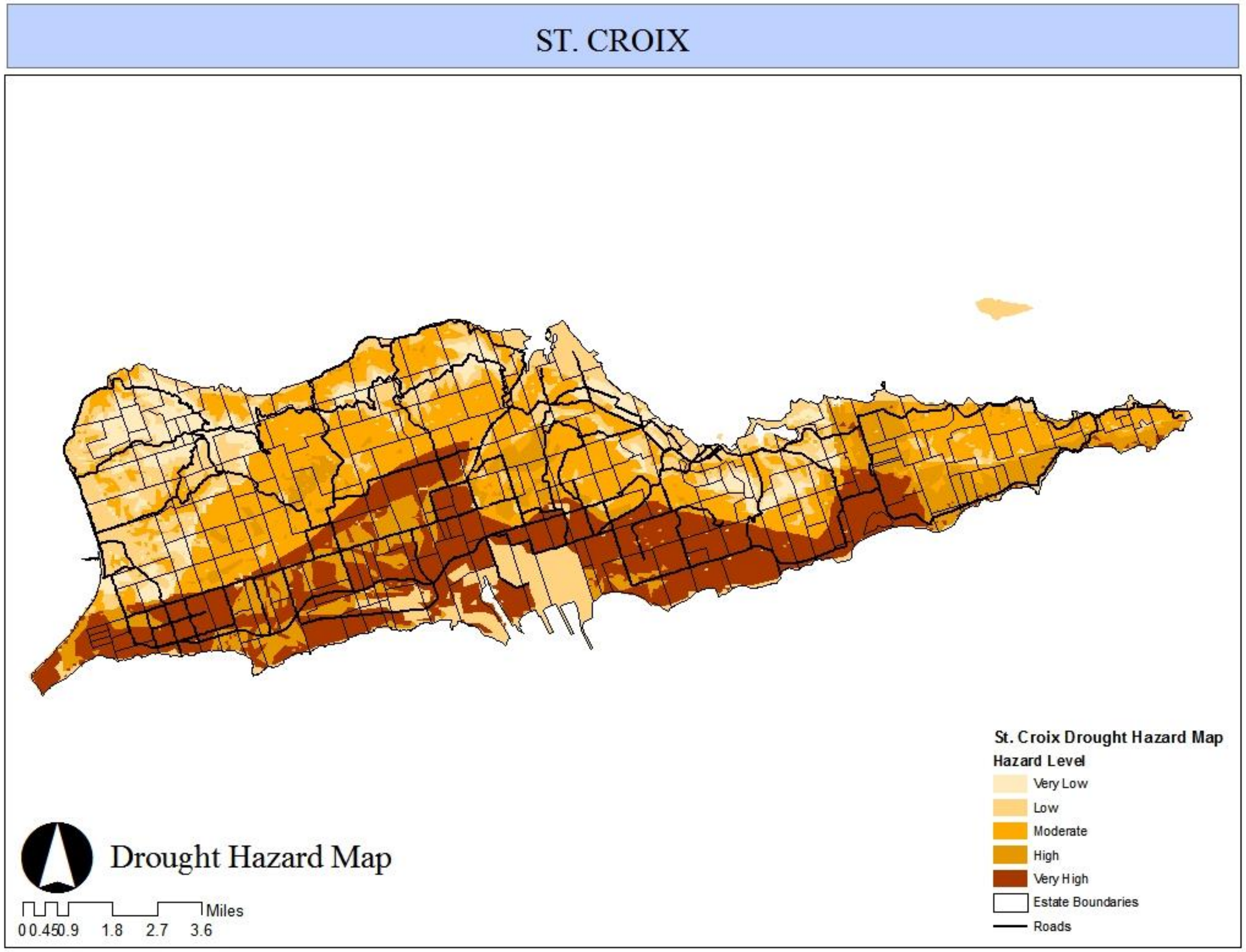
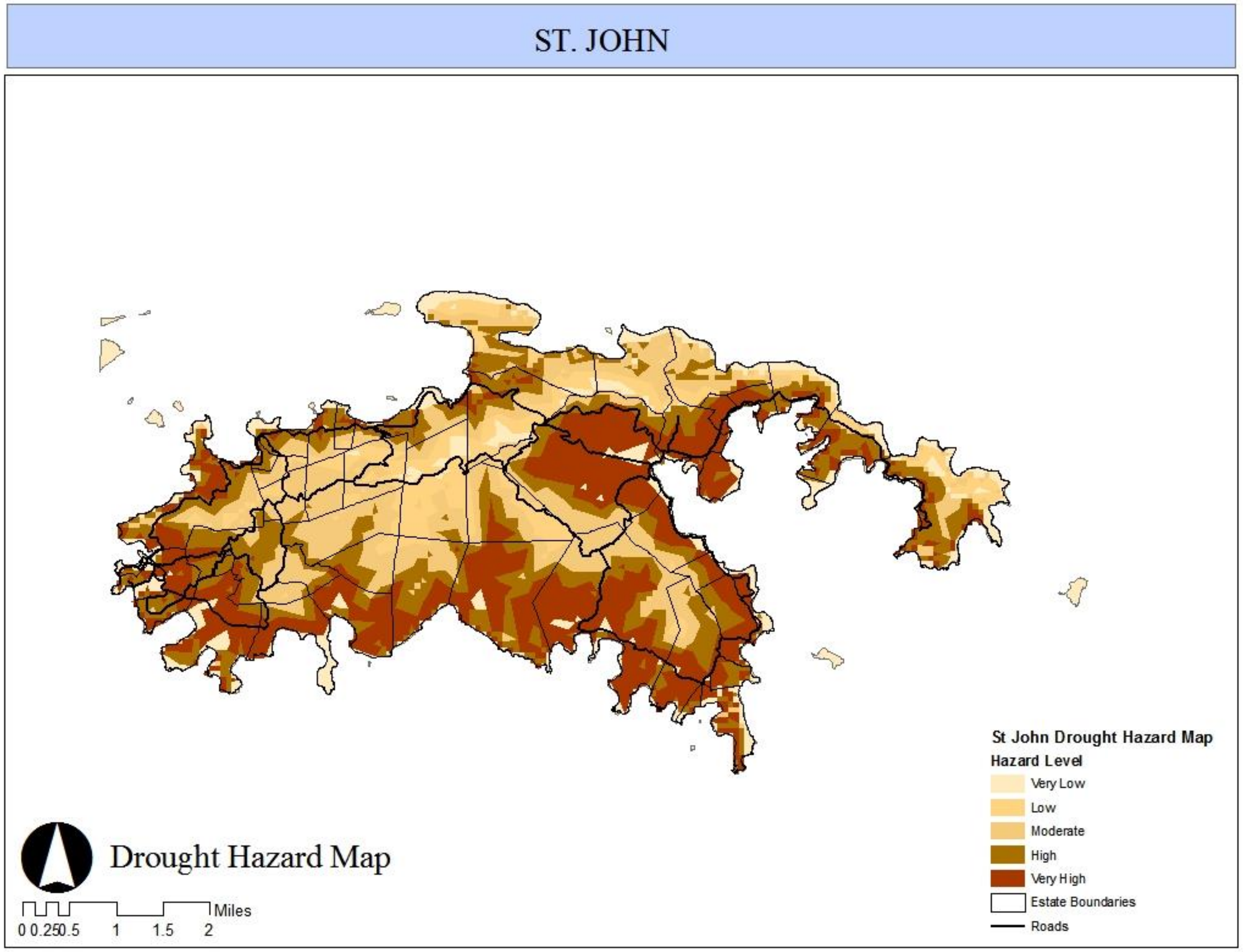


FIGURE 4.4 ***Drought Hazard Map, St. John***



Climate Variability, Hazard Frequency and Magnitude

There is a general lack of understanding on the definition, on-set, and frequency of drought in the U.S. Virgin Islands.

However, based on regional information gathered from the Caribbean Institute for Meteorology and Hydrology and the Brace Centre for Water Resources Management, McGill University, the frequency of drought hazards in the Caribbean will increase due to climate variability.

Taking into consideration climate change data, the McGill University furthers that climate change models indicate that temperatures are very likely to rise (90-99% probability) and that there is expected to be a decrease in annual precipitation in the region of 5 to 15% with the greatest change during the months of June to August.

Such data provides a clear indication that the occurrence of drought events will increase in the future, which in turn means that there is likely to be a decrease in reported incidence of periods defined as having no drought.

Therefore, drought probability, which is tied to annual average precipitation, for Caribbean region which includes the US Virgin Islands is estimated to be 40% below normal[3].

Data Sources, Models and Methodologies

Base Data

- (2010): Average Annual Rainfall 1971 -2000, Oregon State University (OSU) Spatial Climate Analysis Service.
- USACE Digital Terrain Model (2008)
- Hydrologic Units for USVI (2002) U.S. Geological Survey in cooperation with the U.S. Department of Agriculture, Natural Resources Conservation Service.
- The United States, Caribbean and Pacific Basin Major Land Resource Areas (MLRA) Geographic Database serves as the geospatial expression of the map products presented and described in Agricultural Handbook 296 (2006).

Drought Hazard Assessment and Determination

- (2009): The Caribbean Drought and Precipitation Monitoring Network: The Concept and its Progress http://www.wamis.org/agm/meetings/wies09/S3B-Trotman.pdf

[3] Drought and Precipitation Monitoring for Enhanced Integrated Water Resources Management in the Caribbean (2008)

- (2010): Drought Impacts and Early Warning in the Caribbean: The Drought of 2009-2010; Adrian R. Trotman David A. Farrell; http://www.wmo.int/pages/prog/drr/events/Barbados/Pres/4-CIMH-Drought.pdf
- UN/ISDR, 2007. Drought Risk Reduction Framework and Practices: Contributing to the Implementation of the Hyogo Framework for Action. United Nations Secretariat of the International Strategy for Disaster Reduction (UN/ISDR), Geneva, Switzerland, 98+vi pp.
- US National Assessment of the Potential Consequences of Climate Variability and Change Educational Resources Regional Paper: US-Affiliated Islands of the Pacific and Caribbean, http://www.usgcrp.gov/usgcrp/nacc/education/islands/islands-edu-3.htm

Inventory Data (Assets)

- General Building Stock: Office of the Lt. Governor, Office of the Tax Assessor, Computer Mass Appraisal System Database and GIS Parcel Maps
- Critical Facilities and Infrastructure: VI Department of Property and Procurement, VITEMA

4.4.3 EARTHQUAKE

Hazard Description

An earthquake is a sudden motion or trembling of the earth caused by an abrupt release of stored energy in the rocks beneath the earth's surface. The rocks that make up the earth's crust are very brittle. When stresses due to underground tectonic forces exceed the strength of the rocks, they will abruptly break apart or shift along existing faults. The energy released from this process results in vibrations known as seismic waves that are responsible for the trembling and shaking of the ground during an earthquake. Earthquakes are also caused by tremendous rock slides that occur along the ocean floor.

There are several different ways to express the severity of an earthquake. The two most common are: *magnitude*, which is the measure of the *amplitude* of the seismic wave and is expressed by the Richter scale, and *intensity*, which is a measure of how strong the shock was felt at a particular location, expressed by the Modified Mercalli Intensity (MMI) scale. The Richter scale represents a logarithmic measurement where an increase in the scale by one whole number represents a tenfold increase in measured amplitude of the earthquake. Table 4.4 shows the rough correlation between the Richter scale, Peak Ground Acceleration (PGA), and MMI. The relationship between PGA, magnitude, and intensity are, at best, approximate, and also depend upon such specifics as the distance from the epicenter and depth of the epicenter.

TABLE 4.4 ***Earthquake Magnitude / Intensity Comparison***

PGA (in %g)	Magnitude (Richter)	Intensity (MMI)	Description (MMI)
<0.17	1.0 - 3.0	I	I. Not felt except by a very few under especially favorable conditions.
0.17 - 1.4	3.0 - 3.9	II - III	II. Felt only by a few persons at rest, especially on upper floors of buildings. III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
1.4 – 9.2	4.0 - 4.9	IV - V	IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rock noticeably. V. Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
9.2 - 34	5.0 - 5.9	VI - VII	VI. Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight. VII. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
34 - 124	6.0 - 6.9	VIII - IX	VIII. Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
>124	7.0 and higher	VIII or higher	X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent. XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly. XII. Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Source: Wald, D., et al., "Relationship between Peak Ground Acceleration, Peak Ground Motion, and Modified Mercalli Intensity in California."

Nature of the Hazard

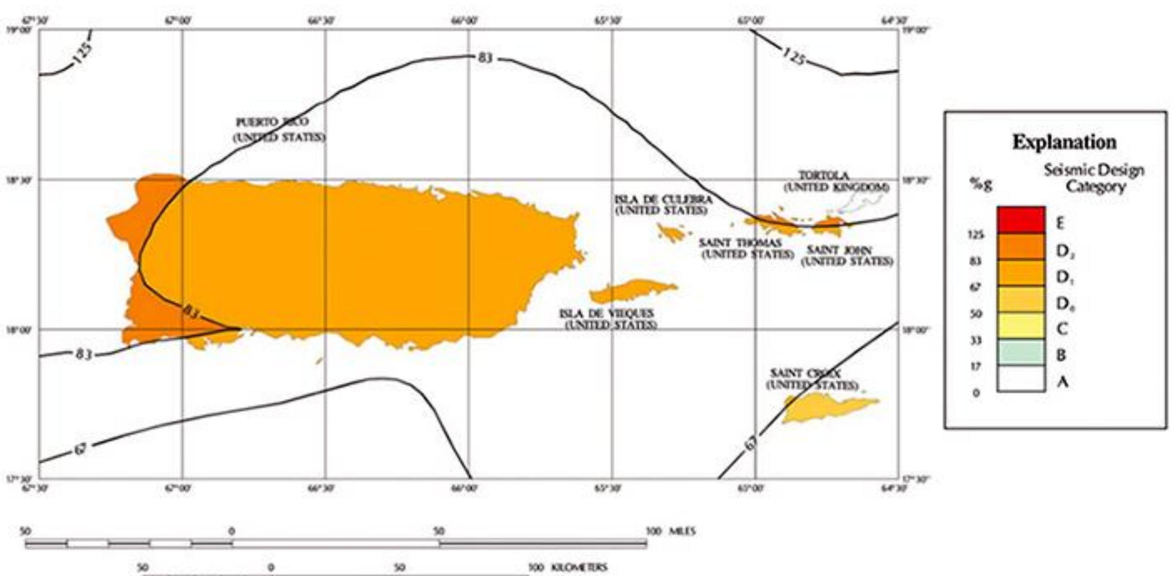
The US Virgin Islands are located on the northeastern edge of the Caribbean Plate. Although there has been what is referred to as a “seismic gap” where no significant events have been recorded for a long period, the area is still considered very seismically active. The US Virgin Islands is actually considered as earthquake prone as many areas of California. However, the difference of these two areas is that the plate that affects the Virgin Islands is deep compared to the rather shallow fault line in California producing less harmful seismic events.

It also appears from research that the rate of attenuation for earthquakes in this region is lower, i.e., earthquake shocks propagate longer and farther in this region given the same initial earthquake intensity, than earthquakes that occur in the northeastern United States (IRF 1984).

The exact configuration of the Caribbean Plate boundary in the vicinity of the Virgin Islands is poorly understood and is also quite complex. The Island of Puerto Rico and all the northern Virgin Islands are considered a “microplate” caught within the plate boundary. Zones of continuing deformation surrounding this microplate pass through the Anegada Passage separating the northern Virgin Islands from St. Croix, as well as along the eastward continuation of the Puerto Rico Trench to the north (EQE International 1994). These two features comprise the principal source of earthquakes that affect the US Virgin Islands.

Generalized seismic maps were developed by USGS to provide guidance for construction in 2010. Figure 4.5 below provides a depiction of the hazard intensity so as to provide guidance to building design and construction professionals. The seismic design categories for Puerto Rico and the Virgin Islands have been developed for low rise occupancy Category I and II structures located on sites with average alluvial soil conditions.

***FIGURE 4.5*: Seismic Design Map for Puerto Rico and the Virgin Islands**



source: http://www.fema.gov/earthquake/earthquake-hazard-maps

The colors in the maps denote “seismic design categories” (SDCs), which reflect the likelihood of experiencing earthquake shaking of various intensities. (Building design and construction professionals use SDCs specified in building codes to determine the level of seismic resistance required for new buildings.) The following table describes the hazard level associated with each SDC, and the associated levels of shaking. Although stronger shaking is possible in each SDC, it is less probable than the shaking described.

TABLE 4.5: Seismic Design Categories

SDC	Map Color	Earthquake Hazard	Potential Effects Of Shaking*
A	White	Very small probability of experiencing damaging earthquake effects.	
B	Gray	Could experience shaking of moderate intensity.	Moderate shaking—Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
C	Yellow	Could experience strong shaking.	Strong shaking—Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built structures.
D0	Light brown	Could experience very strong shaking (the darker the color, the stronger the shaking).	Very strong shaking—Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures.
D1	Darker brown		
D2	Darkest brown		
E	Red	Near major active faults capable of producing the most intense shaking.	Strongest shaking—Damage considerable in specially designed structures; frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations. Shaking intense enough to completely destroy buildings.
* Abbreviated descriptions from The Modified Mercalli Intensity Scale.; source: http://www.fema.gov/earthquake/earthquake-hazard-maps			

The Puerto Rico Trench runs E-W about 100 km to the north of Puerto Rico and the northern Virgin Islands. The deepest section of the trench, approximately 8 km, is located to the north of Puerto Rico. The Anegada Passage fault zone extends for approximately 375 km north-east and comprises a series of interconnected basins up to 4.4 km deep. This deep trench separates St. Croix from the Puerto Rico – Virgin Islands platform (EQE International 1994).

Hazard Location, Extent and Distribution

The extent of the earthquake risk is not uniform territory wide. Figure 4.8 illustrates the geographic coverage of earthquake hazard prone areas on the three major islands.

St. Thomas and St. John have been formed as a result of underwater volcanic flows and can be considered to have very similar geology. Both islands have a thin soil cover of sedimentary deposits, limestone, alluvium and recent beach deposits. The Cretaceous-aged Louisehoj and Water Island formations are highly weathered, jointed and fractured (Geoscience Associates 1984). From a geologic stand point the islands are essentially the same land mass, separated by a garden, Pillsbury Sound. .

As illustrated in the maps (Figure 4.6, 4.7 and 4.8), the hazard intensity varies throughout St. Thomas and St. John. On both islands, hillsides are susceptible to earthquake induced land sliding. Geoscience Associates (1984) point to several causes that have increased susceptibility on these islands. They include: increased hillside development; removal of slope vegetation; and steeper man-made slopes. Other critical areas include the waterfront area of Charlotte Amalie that is built upon alluvial soils and various land fill. The performance of such materials is notoriously poor.

FIGURE 4.6 ***Earthquake Hazard Map, St. Thomas***

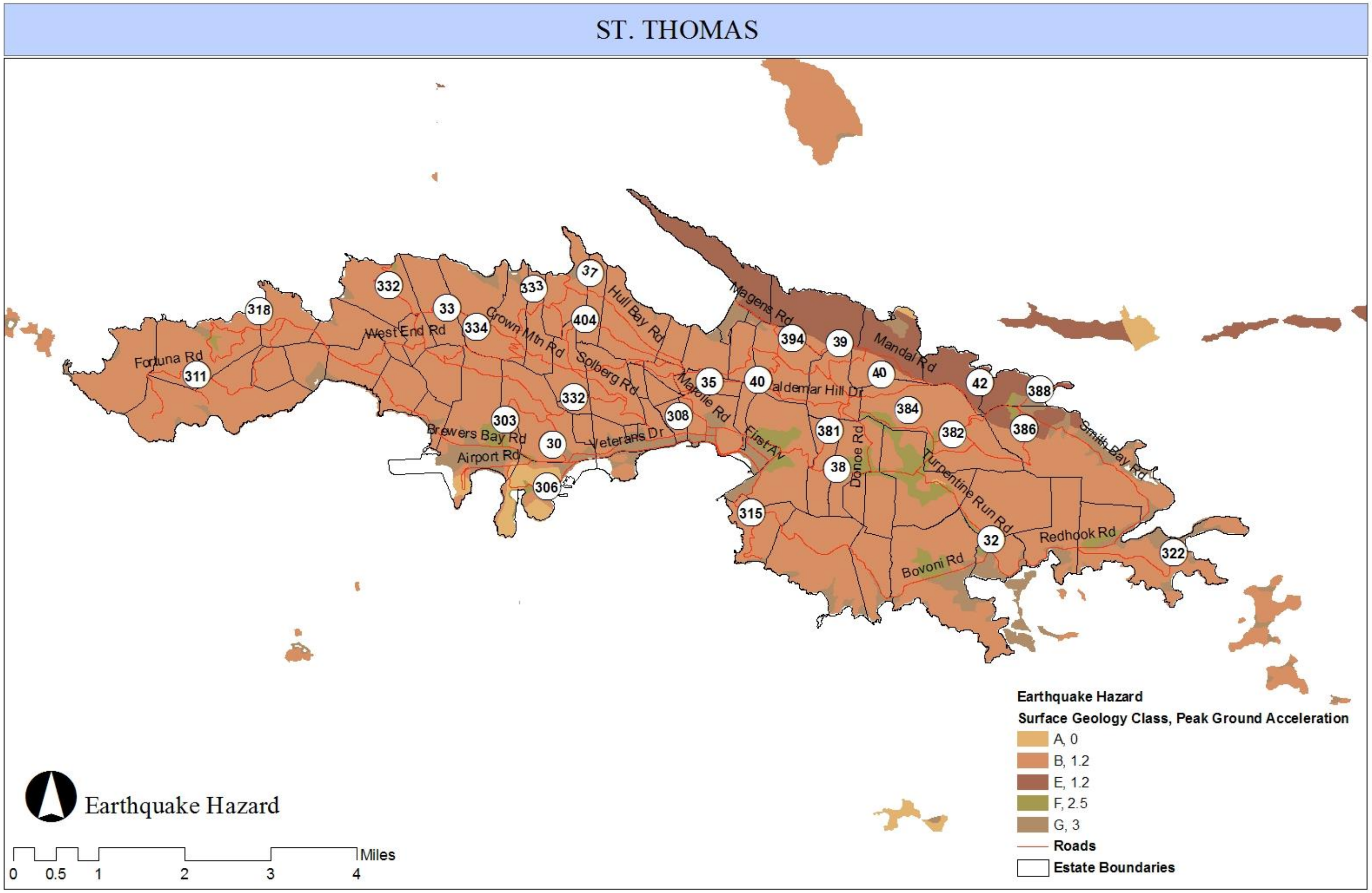


FIGURE 4.7 ***Earthquake Hazard Map, St. Croix***

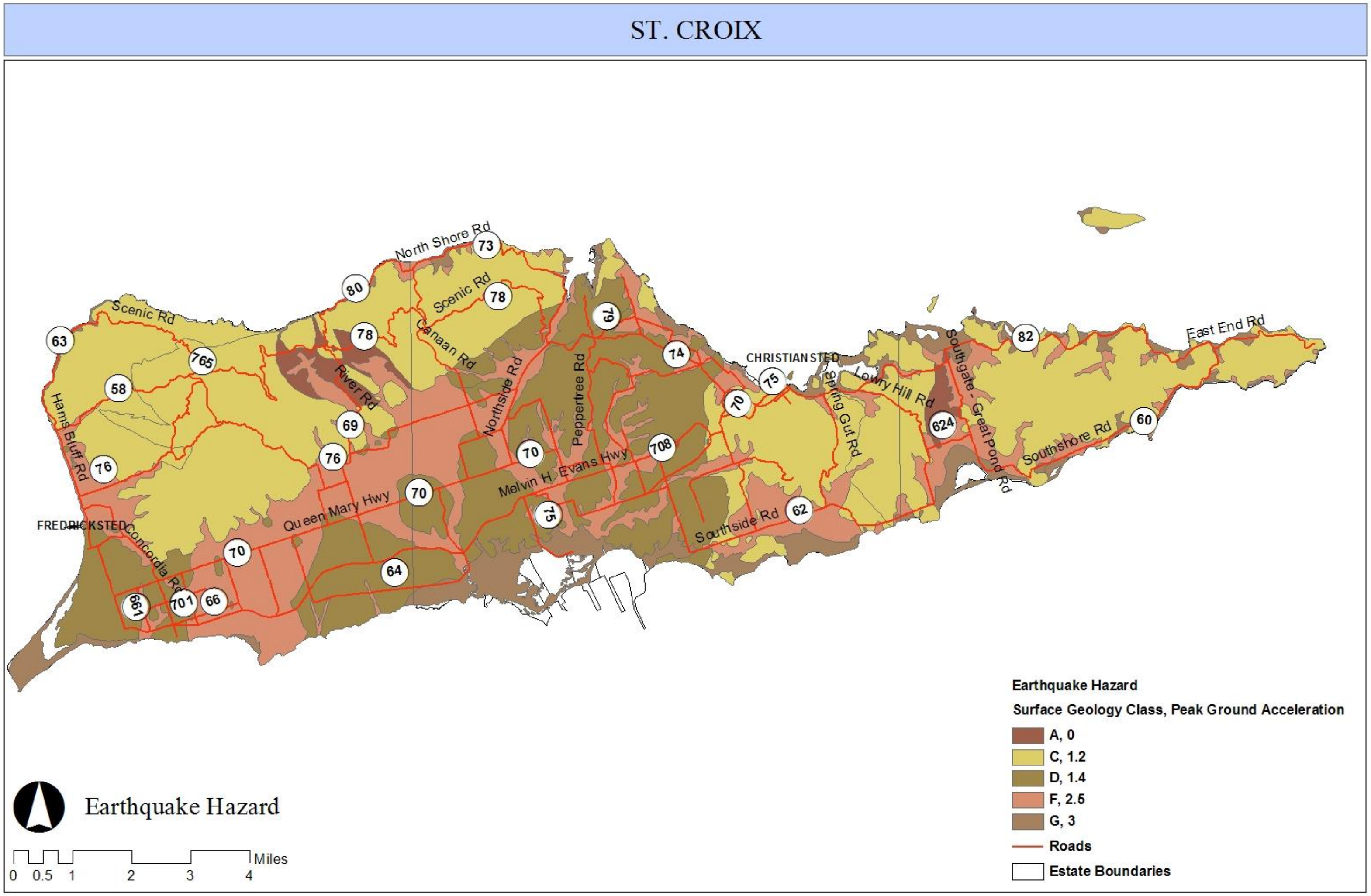
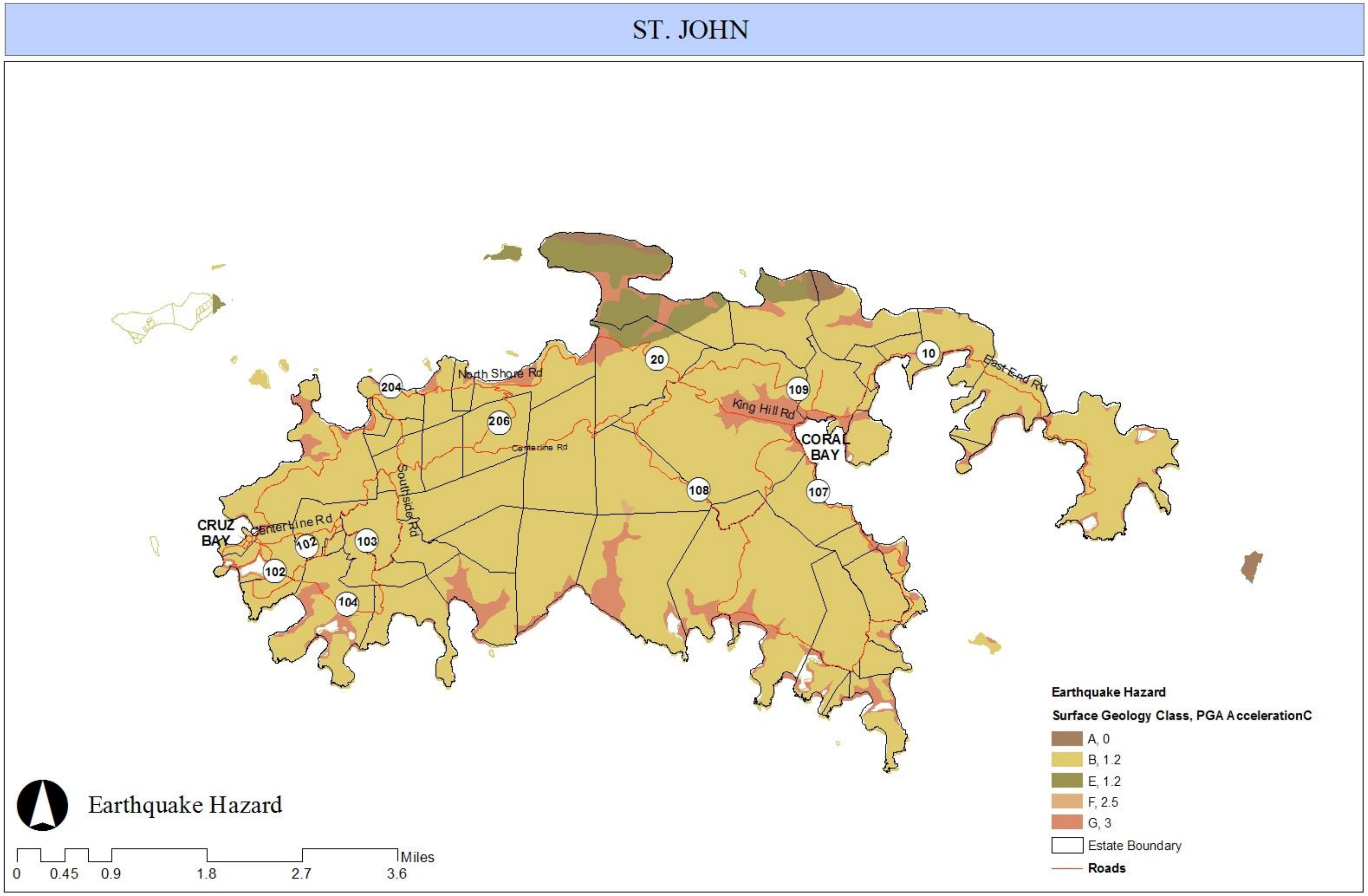


FIGURE 4.8 ***Earthquake Hazard Map, St. John***



St. Croix is not volcanic in origin. Its soils and rock formations have developed from sedimentary processes. The major rock types of St. Croix are siltstones, limestone, sandstones, conglomerates, marls, volcanic ashes, and minor granite intrusives. The rock formations are tilted up to near vertical orientation. The rock formations include Caledonia, Allandale, Cane Valley, and Judith Fancy formations, all of late Cretaceous age (Geoscience Associates 1984).

Much of Christainsted and Frederiksted waterfronts mimic the performance of the waterfront areas on St. Thomas. Much of the town of Frederiksted is supported on residual soils of the Kingshill Marl Formation, the most granular faces of which appeared to be liquefaction prone (Geoscience Associates 1984). Christiansted is built upon alluvial soils and various land fill also making it prone to liquefaction. On St. Croix, there are widespread structural concerns throughout the island. The 1984 Geoscience Associates report points out that hillside construction on St. Croix, especially houses supported on stilts, are quite susceptible to earthquakes.

Disaster History

There is a verifiable record of earthquake occurrences dating back more than 500 years. More than 200 "felt events" have been recorded in the area since the first reliable report on September 1, 1530 near the coast of Venezuela. The first recorded incident directly affecting what is now the US Virgin Islands was in 1777, when a shock with an estimated intensity on the Modified Mercalli scale of IV-V was reported on St. Thomas (see Table 4.4). Over the next two hundred years, as many as 170 individual events were recorded (IRF, 1984) but none have been of great consequence since 1867 when an earthquake estimated at MMI VIII on St. Thomas and VII-VIII on St. Croix as recorded. Since that time there have been no major events with the highest estimated intensity measured at MMI IV-V. Due to the moderate nature of these events and their non-destructive nature there has been no Federal disaster declaration for any of these occurrences

It is worth noting; however, that the Puerto Rico Seismic Network, for its area of responsibility (latitude 17.00 -20.00˚ N and longitude -63.50 -69.00˚), and for the period from April 2011 to April 2014 there have been 65 seismic events with a magnitude of 4.0 or greater on the Richter Scale. The strongest of these was an event that had a magnitude of 6.4 on the Richter Scale and occurred in the Puerto Rico on January 13, 2013.

Clearly the event that stands in our minds is the event in Haiti on January 2010. The 2010 Haiti earthquake was a catastrophic magnitude 7.0 Mw earthquake, with an epicenter near the town of Léogâne, approximately 25 km (16 miles) west of Port-au-Prince, Haiti's capital. An estimated three million people were affected by the quake; the Haitian government reported that an estimated 316,000 people had died, 300,000 had been injured and 1,000,000 made homeless.[4]

The region from Puerto Rico to the Virgin Islands is seismically active. In 2010, the majority of earthquakes occurred along the Puerto Rican Trench. This is worth noting, as in 2009, most earthquakes had epicenters massed to the north of the Virgin Islands. Earthquakes (above 4.0) averaged nineteen (19) per year.

4 a b "Red Cross: 3M Haitians Affected by Quake". CBS News. 13 January 2010. Retrieved 13 January 2010.
^ "Haiti raises earthquake toll to 230,000". AP. The Washington Post. 10 February 2010. Retrieved 30 April 2010.
^ "Haiti will not die, President Rene Preval insists". BBC News. 12 February 2010. Retrieved 12 February 2010.

Hazard Frequency and Magnitude

It has been estimated that an earthquake with the same magnitude as the 1867 earthquake event would have a 300 to 5,000 year recurrence interval (RI). For practical purposes, this is a longer RI than is useful for planning and design purposes. However, there are two useful references for assessing the probability of an earthquake of destructive proportions in the US Virgin Islands, the first of which uses the same value as the 1867 event.

The first is the “design earthquake” recommended by the Natural Hazards Planning Council. The Council selected a “design earthquake”[5] of level MMI VIII for use by engineers and planners to prevent damage from events that they believed have a reasonable expectation of occurring in the US Virgin Islands (IRF, 1984) given the region’s general seismicity. The second reference is from a study prepared for the US Virgin Islands Water and Power Authority (WAPA, 1994). In this study, the authors determine that the earthquake intensity likely to have a recurrence interval on the scale of 100 years is in the MMI VI-VII range. Based on this estimate (100-yr), the US Virgin Islands has a 1/100 or a 1% annual probability of an event in the MMI VI-VII range.

The Seismic Hazard Map of 1994 (Earth Science Consultants, 1999), which provides ground shaking intensity (expressed in terms of Peak Ground Acceleration (PGA) for 50-, 100-, 250-, and, 1,000-year return periods). This study, utilized the 1000-year ground shaking map. This map was generated using an acceleration variability (σ) of 0.6 at a set of sites across each island. The Peak Ground Acceleration (PGA-%g) ranges from .48 to .91g for a 1000-year return period. Based on this return period (1000-yr), the US Virgin Islands has a 0.1% percent annual probability of observing the losses shown in this risk assessment.

Data Sources, Models and Methodologies

Information for the development of the Earthquake Risk Assessment came from a variety of sources, including:

Base Data (Earthquake)

5 design earthquake event is used for estimating the demands and predicting the supplies of the real three-dimensional soil-foundation-building system performance during an event.

- 1000-year probabilistic ground shaking intensity maps (Earth Scientific Consultants 1999).
- Earthquake vulnerability maps, which classified acceleration factors for local site geology, using NEHRP[6] provisions to define localized site amplification classification (Earth Scientific Consultants, 1999)
- Charles Mueller, Arthur Frankel, Mark Petersen, and Edgar Leyendecker (2010) New Seismic Hazard Maps for Puerto Rico and the U.S. Virgin Islands. Earthquake Spectra: February 2010, Vol. 26, No. 1, pp. 169-185.

Earthquake Hazard Assessment and Determination

- The hazard assessment was developed using the Seismic Hazard Map of 1994 (Earth Science Consultants, 1999), which provides ground shaking intensity (expressed in terms of Peak Ground Acceleration (PGA) for 50-, 100-, 250-, and, 1,000-year return periods)
- The 1000-year ground shaking map was generated using an acceleration variability (σ) of 0.6 at a set of sites across each island. Acceleration factors were identified based on local soil conditions and the surficial geology.
- Local site geology was classified using NEHRP provisions to define localized site amplification classification.
- GIS overlay techniques were used to assign an earthquake susceptibility factor (PGA) to. each estate.

Inventory Data (Assets)

- General Building Stock: Office of the Lt. Governor, Office of the Tax Assessor, Computer Mass Appraisal System Database and GIS Parcel Maps
- Critical Facilities and Infrastructure: VI Department of Property and Procurement, VITEMA

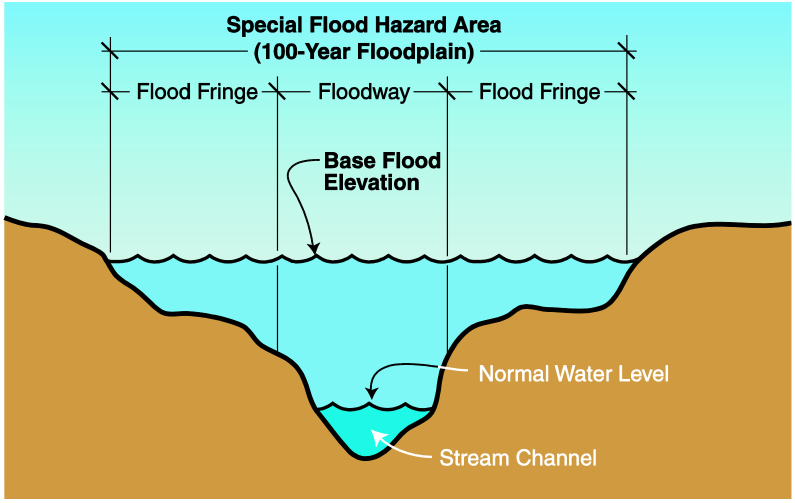
[6] NEHRP is the National Earthquake Hazards Reduction Program. This program's congressional mandate is "to reduce the risks to life and property from future earthquakes in the United States through the establishment and maintenance of an effective earthquake hazards reduction program".

4.4.4 RIVERINE FLOODING

Hazard Description

Floods are naturally occurring events for rivers and streams. Excess water from rainfall accumulates and overflows onto banks and adjacent floodplains — lowlands adjacent to guts, streams, or rivers that are subject to recurring floods (see Figure 4.9 below).

Figure 4.9 ***Definition Sketch for Floodplains***



Source: *Understanding Your Risks* – FEMA Publication 386-2, Page 2-12

FEMA's National Flood Insurance Program (NFIP) maps many floodplain boundaries. The *Digital Flood Insurance Rate Maps (DFIRMs)* have been updated and reissued in April 2007. They have been provided to the Territory. These maps provide the Territory with a more useful resource for planning and site specific decision making related to flood hazards. The *2007 US Virgin Islands Digital Flood Insurance Rate Maps (DFIRMs)* are used as reference for the National Flood Insurance Program. The Flood Insurance Study; however, provides more detailed information in certain areas where Base Flood Elevations (BFEs) and/or floodways have been determined.

Historically, floods often exceed the mapped floodplains in the Virgin Islands. The 2007 Flood Insurance Study for the US Virgin Islands indicates that the principle causes of flooding are associated with storm water run-off. In addition, flooding is caused by encroached upon artificial fills and structures (e.g., filling in floodplain or floodway areas, or increased imperviousness within the watershed from new development) and where guts in many areas are filled with debris (e.g., accretion, erosion, sedimentation, etc.).

Nature of the Hazard

Heavy floods are a common feature of Caribbean islands. This is due to tropical weather patterns that are exacerbated during hurricane season from June to November and to higher seasonal rainfall in the fall months of August, September, October and November. There have been a number of large-scale devastating flooding events through time. Historically, most of these large-scale events have had the greatest impact outside of the island's urban areas. Inland flooding from more frequent, but smaller storm events, has caused more cumulative damage over the long run in the more urbanized areas in the US Virgin Islands, although it is less damaging on an event-by-event basis.

The islands' mostly hilly to rugged and mountainous terrain, especially on St. Thomas and St. John, is coupled with thin soils and non-porous rock substrata. The steep drainage ditches or "guts" that receive most of the runoff create optimal conditions for over-bank flooding problems. Added to this natural tendency to generate flooding conditions are the following:

- Increases in impervious surfaces in the urbanizing areas of the islands as seen in Frenchtown Area in St. Thomas; Sub base Area in St. Thomas; Christiansted Area in St. Croix; Cruz and Coral Bay on St. John
- The placement of undersized culverts where roads cross guts as witnessed in Dorethea in St. Thomas or Gallows Bay in St. Croix;
- A failure to upgrade storm water management facilities to meet the needs of on-going development (i.e. Enighed Pond St. John),
- Lack of consistent maintenance of other storm water management facilities (i.e. Radets Gade St. Thomas, Garden Street on St. Thomas); and
- Encroachments to the floodplain built over many years (i.e. La Grande Princess in St. Croix).

As highlighted above, frequent inundation of property persists. Many of these problems are highlighted in the Mitigation Strategy and Severe Repetitive Loss Strategy of this Plan Update.

Hazard Location, Extent and Distribution

Figure 4.10, 4.11, and 4.12 illustrate the geographic coverage of riverine flooding on the three major islands. The extent and geographic distribution of the regulated 100-year floodplains differ amongst the three islands due to their geology, topography, soils, and rainfall distribution patterns.

The island of St. John overall topographic profile is lower than nearby St. Thomas. However, the average annual rainfall is the greatest of the three major islands of the Territory with 54" compared to 44" on St. Thomas and 40" on St. Croix. The steep terrain of St. John concentrates runoff in natural guts that transverse to the sea. Flooding, like all hazards, is not a problem unless development or infrastructure alters the landscape. This is because the majority of the island is a National Park and remains in its natural state. Coral Bay and the surrounding area have experienced rapid development without regard for effective storm water drainage systems both in the highland areas and lowland environs. The former disregard intensifies the problems of the latter.

Most of the flooding occurs in Cruz bay or Coral Bay. These areas are prone to flooding as they are both located at the bottom of steep hills. Problems are caused by development without regard for sufficient drainage and inadequate drainage systems or improper engineering for the critical roadways. Although these manifestations cause localized flooding the problem is severe enough to disrupt commerce and emergency access. Particular areas of concern identified by citizens include: Poor or inadequate storm water drainage infrastructure on Centerline and Bordeaux Mt. Roads; need to improve storm water drainage infrastructure to alleviate localized flooding at the Guy Benjamin School in Coral Bay; water drainage system at Guinea (Westin) Gut and localized flooding at Enighed Pond (i.e. WAPA building and treatment plant and areas of Route 102 and Route 104 by the Tennis Court).

St. Thomas, like St. John, is volcanic island, with steep terrain and significant topographical relief. The island is rather heavily developed with two major urban areas, an extensive road network and the accompanying infrastructure. The areas with the most serious flooding problems are in Estate Nadir. This is essentially a continuous drainage system with the drainage channel in Estate Nadir connecting with the natural gut (Turpentine Gut). In the event of heavy rains the Gut and man-made channels have proved to be inadequate to handle the water runoff from the surrounding hillside.

Flooding persists on the East End of the island, particularly in Red Hook, where intensive commercial development has put pressure on drainage infrastructure. The inadequate storm water drainage system in Frydenhoj (next to and across from ball field) has caused localized flooding to commercial and residential structures. The development of many residences in the East End area has either altered the natural flow of runoff or increased the impervious surface area through the construction of the residences and the attending access roads and driveways.

This is witnessed on Bolongo Bay Road from Intersection Hill going up to Sea View Home to the Bolongo Bay Hotel. Additionally, the flooding problem in the Tutu community is also exacerbated by dense development without regard for natural water runoff and an insufficient drainage system throughout the entire community, but especially along the valley floor. These problems are manifested at the Tutu Fire Station, a critical facility and adjacent to Metro Motors and Gomez school.

Charlotte Amalie is also impacted by flooding. This historic community does not have adequate systems for water runoff causing flooding to the business district and adjacent areas. There are a few guts for runoff but their maintenance is not consistent and of their overflow is frequently due to debris accumulation. The major runoff system is the Frenchtown Gut. This has a shallow pitch that flows into the harbor and in the event of torrential rains tends to backup and flood a rather large surrounding area. The historic business district is prone to shallow flooding that is caused by lack of an ample drainage infrastructure.

Throughout the island there are other areas of localized flooding where development and insufficient drainage systems allow for water accumulation. Severe flooding has taken place on lower Commandant Gade (Garden Street) and Norre Gade (Main Street) where commercial and residential structures have been flooded. Further to the west of town, existing storm water drainage infrastructure systems on highway from Pueblo to Addelita Cancryn School (sub base) and from Pueblo (sub base) to Crown Bay Port Facility continue to flood and cause traffic disruption, particularly when cruise ships are in port. Inadequate storm water drainage infrastructure continues to plague residential areas of Bournefield north through Kirwin Terrace Public Housing Units.

The geology of St. Croix is vastly different from either St. John or St. Thomas. The geologic history of the island is of a sedimentary origin and the major rock formations are limestone. The result is a landscape with much less topographic relief than St. Thomas. The center of the island is relatively flat, almost a plateau type of landscape. The steep terrain on the island is found along much of the coastline and in hilly, rolling terrain in the northwest portion of the island. There are extensive areas of riverine floodplains throughout St. Croix. However, due to the generally hilly rather than mountainous terrain, the natural flow of runoff water is less rapid causing the accumulation of flood waters to dissipate more slowly.

Consequently most natural waterways are subject to shallow flooding with a slow rise in flood depths. This is prevalent in Estate Welcome, Mon Bijou, La Reine, Williams Delight, Hannah's Rest, St. Georges and areas along Center Line Road. Western areas of Christiansted are prone to flooding in which problems are caused principally by poor siting design and/or developments without regard to adequate drainage systems. Improper drainage systems on road ways have exacerbated problems and have increased downstream flooding in areas like Gallows Bay and Spring Gut; in the vicinity of Paul E. Joseph School; the Grove at La Raine; Frederiksted Lagoon Area; on Prince Street (Christiansted); on King Cross Street (Christiansted); Fort Frederik Beach; East Golden Rock on Rt. 75 (North Shore Road) and the La Grange Gut and associated drainage systems.

FIGURE 4.10 ***Riverine Flooding Hazard, St. Thomas***

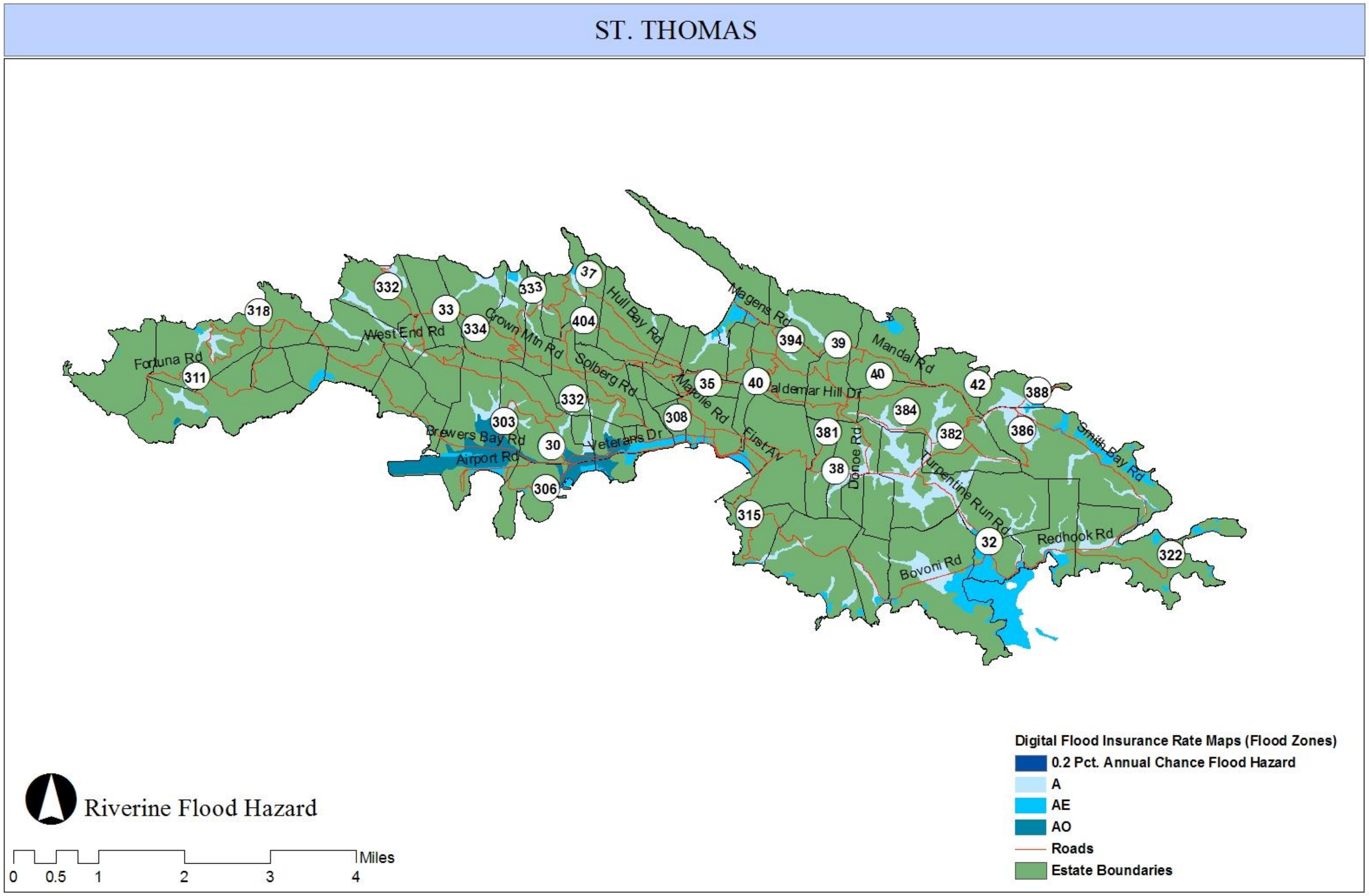


***FIGURE 4.11* Riverine Flooding Hazard, St. Croix**

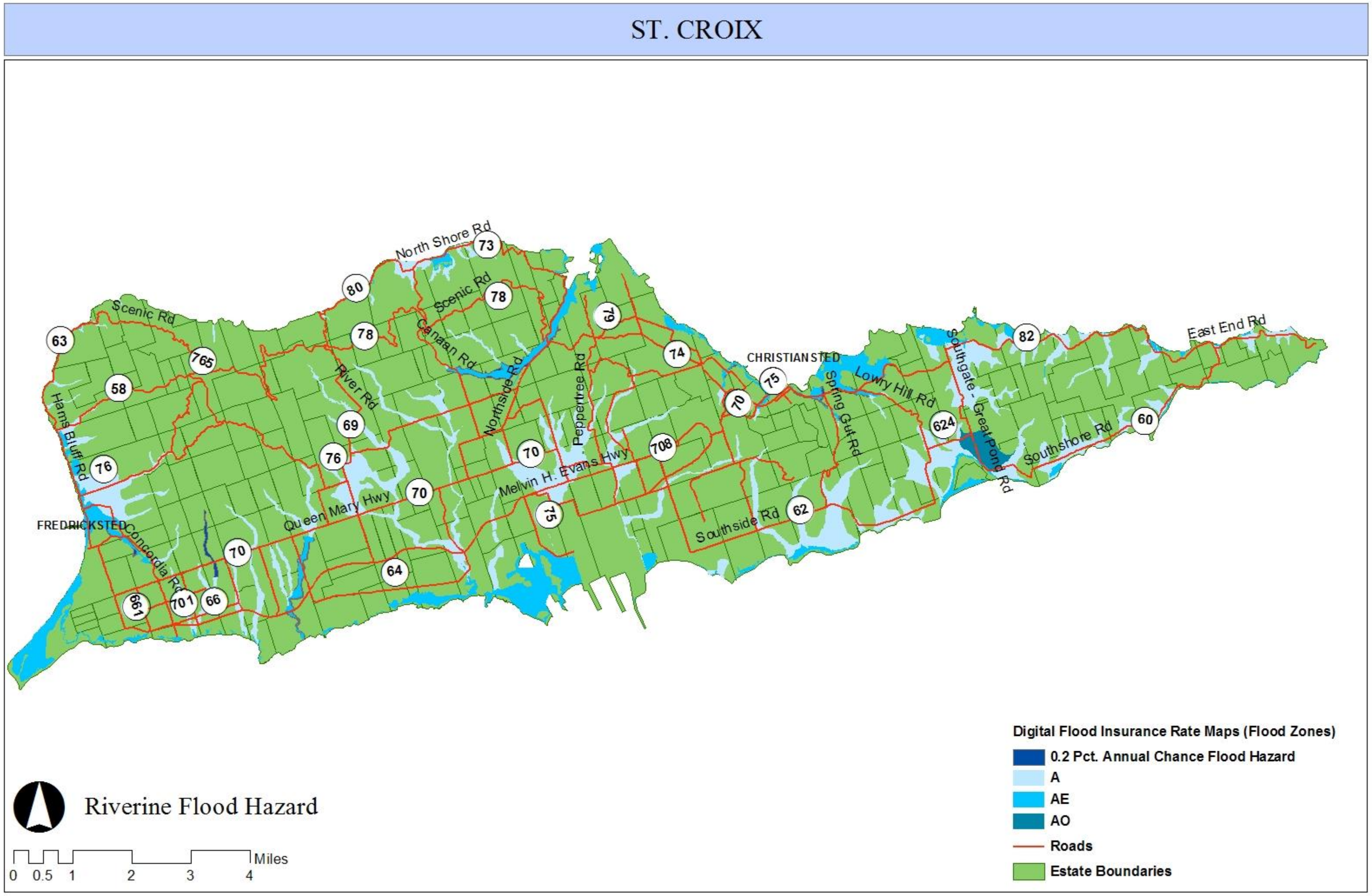
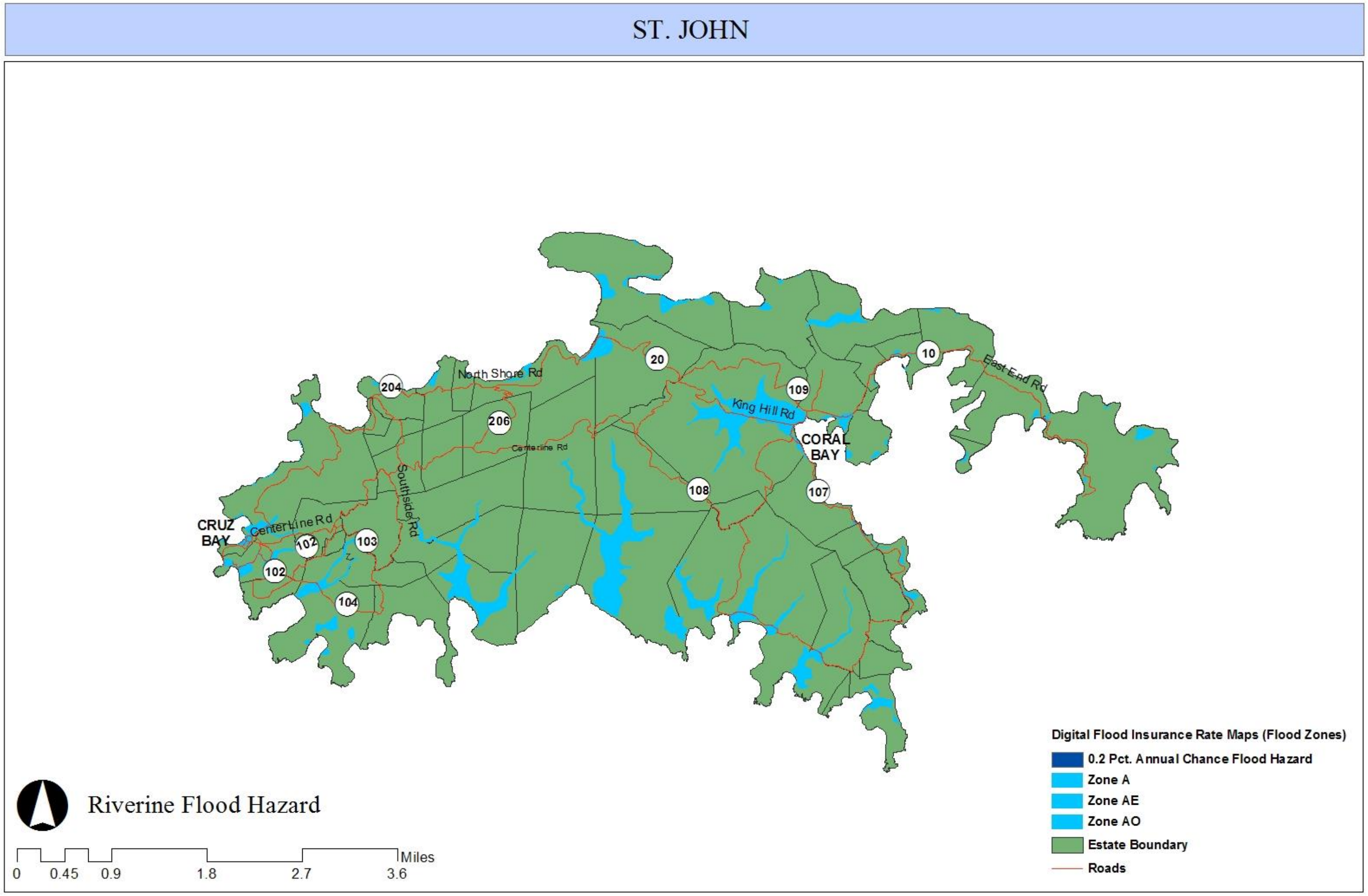


***FIGURE 4.12* Riverine Flooding Hazard, St. John**



Disaster History

Since the 2008 Plan development, there have been 4 Federal disaster declarations, of which 2 have been caused by a prolonged period of heavy rainfall. There is a lengthy record of the rainfall amounts that have occurred in the US Virgin Islands. There is also a good understanding of the factors that lead to riverine flooding as it is experienced in the US Virgin Islands as explained above. However, reliable records for specific occurrences of inland flooding are scarce which makes the reconstruction of many past floods and the determination of recurrence intervals difficult if not impossible. There are studies that have attempted to link higher than normal rainfall events with probable flood events but the results are not conclusive. But, there are good records for a few recent events.

In 2003, heavy rains over the US Virgin Islands during the week of November 12th led to widespread flash flooding. The US Virgin Islands was declared a federal disaster area with damages estimated at $25-30 million. The storm was the result of a two-day period with a stationary area of low pressure, which led to widespread and continuous rainfall across all the US Virgin Islands resulting in generalized flash floods and riverine flooding. This two-day period was followed by a series of showers that lasted for several more days. With the previous heavy rains, the ground was so saturated that most of the subsequent rain became runoff and contributed to additional flooding problems. The four-day accumulation of rain varied from 15 to more than 20 inches across the Islands.

Other significant flooding events have occurred on the island of St. Croix. In November 2004 heavy rains caused severe roadway flooding from Estate Mount Welcome to Gallows Bay depositing large quantities of dirt and debris at the Gallows Bay intersection. There was also general street flooding in Christiansted. In May 2005, severe thunderstorms brought as much as 2 and 3 inches of rain in a one hour period, causing wide spread street and gut flooding in town (Christiansted).

During October 2006, flash flooding caused an accumulation of one foot of water in the Gallows Bay area. This weather system also flooded portions of Mon Bijou, La Reine, Williams Delight, Hannah's Rest, St. Georges and areas along Centerline Road. This system also forced school and business closures. The areas on St. Croix most affected by this event were western suburbs of Christiansted. However, excessive flooding was also reported in Frederiksted, along the South Shore Road and the Northside Road.

In November, 2010, the Territory experienced torrential downpours associated with Tropical Storm Otto and Tomas. The flooding caused extensive damages throughout the islands and flooded cars, businesses, homes and streets. Areas of Charlotte Amalie were affected on St. Thomas where several stores in the historic shopping district were flooded. The Diamond Center was flooded with more than 2 feet of water. On Brookman Road, the tremendous volume of water rushing over the asphalt caused it to lift, prompting temporary closure of that road.

The passing of these systems presented major challenges to the Public Works crews, and while all roads on St Thomas and St John were passable, DPW recommended caution given the saturated soil conditions.. On St. John, flooding was particularly severe in the area of Enighed Pond. Sewers were overwhelmed in several locations and manhole covers were carried away as dirty water flowed down the streets.

On St Croix, roadways flooded and water pooled in several urban areas in Christiansted and Fredricksted, in places where motorists had not seen water standing before, causing some to stall out in the heavy downpours. The runoff from the rains collapsed a section of roadway that spans Gut#5 within Enfield Green cuttingthe Westside of that neighborhood off to vehiclar traffic and leaving no exit. The rush of rain runoff coming down from the hills and making its way to the sea overwhelmed storm water drainage infrastructure in William's Delight and Enfield Green. This high velocity flow caused a culvert crossing on the road within Enfield Green to give way.

In La Vallee on the island's North Shore, landslides and localized flooding in low-lying areas created some hazards by pushing debris into the roadways. There were weather-related electrical failures in Orange Grove, LBJ Gardens, Montpellier, Betsy Jewel, Grove Place, La Reine, Castle Coakley, Whim, William's Delight, Two Williams, Mt. Pleasant, Shoys, La Grange, Butler Bay, Spring Garden, Northside, Nicholas, Frederikshaab, Wheel of Fortune, Little Princess Hill, St. John, Grange Hill, Brookshill, Turner Hole, New Works, Bethlehem, and Mon Bijou.

Climate Variability, Hazard Frequency and Magnitude

Floods are described in terms of their extent (including the horizontal area affected and the vertical depth of floodwaters) and the related probability of occurrence. Flood studies use historical rainfall records and physical land characteristics to determine the probability of occurrence for different extents of flooding. The probability of occurrence is expressed in percentages as the chance of a flood of a specific extent occurring in any given year.

A specific flood that is used for a number of purposes is called the “base flood” which has a 1% chance of occurring in any particular year. The base flood is often referred to as the “100-year flood” since its probability of occurrence suggests it should only reoccur once every 100 years, although this is not the case in practice. Experiencing a 100-year flood does not mean a similar flood cannot happen for the next 99 years; rather it reflects the probability that over a long period of time, a flood of that magnitude should only occur in 1% of all years.

TABLE 4.6 ***Flood Probability Terms***

Flood Recurrence Intervals	Chance of occurrence in any given year
10 year	10%
50 year	2%
100 year	1%
500 year	0.2%

While the FEMA flood maps that were utilized for this assessment they do not incorporate the impacts of climate change, it will become an increasing important parameter for predicting flood hazard and mapping the extent of flood hazards.

To incorporate climate change into flood models FEMA flood mapping experts must work to incorporate projected data for future climatic conditions into hydrological and hydraulic models, which can be used to delineate the extent of flooding for certain return periods.

Since climate models indicate that there is a likely to be a potential increase in extreme rainfall events, it will be important to monitor such data to understand changes in susceptibility to flooding due to climate change throughout the territory. Greater frequency of intense rainfall events will translate into larger (deeper and more widespread) floods occurring in the Territory more often. Table 4.6 shows a range of flood recurrence intervals and their probabilities of occurrence.

The extent of flooding associated with a 1% probability of occurrence – the base flood - is used as regulatory boundaries by Federal, state and local agencies. Also referred to as the “Special Flood Hazard Area (SFHA)” (see Figures, 4.10, 4.11 and 4.12), this boundary is a convenient tool for assessing vulnerability and risk in flood prone communities, since many communities have maps available that show the extent of the estimated base flood event.

Data Sources, Models and Methodologies

Information for the development of the Riverine Flood Risk Assessment came from a variety of sources, including:

Base Data (Riverine Flooding)

- FEMA Digital FIRM data, which delineate the 100- year floodplain and VE SFHA boundaries
- USACE Digital Terrain Model

Riverine Flood Hazard Assessment and Determination

- FEMA Digital FIRM data were identified as the most comprehensive flood polygon data for the US Virgin Islands. This data was updated in April, 2007. GIS overlay techniques were utilized to identify structures in the flood zone flood polygons. Flood depths were estimated for each estate on each island by overlaying the Q3 flood zone data on a digital elevation model.

Inventory Data (Assets)

- General Building Stock: Office of the Lt. Governor, Office of the Tax Assessor, Computer Mass Appraisal System Database and GIS Parcel Maps
- Critical Facilities and Infrastructure: VI Department of Property and Procurement, VITEMA

4.4.5 COASTAL FLOODING & EROSION

Hazard Description

The most dangerous and damaging feature of a coastal storm is storm surge. Storm surges are large waves of ocean water that sweep across coastlines where a storm makes landfall. The more intense the storm, the greater the height of the storm surge.

Storm surge areas can be mapped by a number of computer-driven models. The coastal hazard mapping was developed for the USACE using the SLOSH (Sea, Lake, and Overland Surges from Hurricanes) computer model (developed by the National Weather Service to forecast surges that occur from wind and pressure forces of hurricanes), Bathymetry and coastline topography. The SLOSH model was developed primarily as an emergency management tool to aid in evacuation planning. In the USVI, hurricane category is the predominant factor in "worst case" hurricane surges. The resulting inundation areas are grouped into Category 1 and Category 3, and Category 5 classifications. The hurricane category refers to the Saffir-Simpson Hurricane Intensity Scale described in Table 4.7.

TABLE 4.7 ***Saffir-Simpson Hurricane Scale***

Category	**Storm Surge** (feet above normal sea level)
1	4–5 ft.
2	6–8 ft.
3	9–12 ft.
4	13–18 ft.
5	> 18 ft.

The IPCC Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5) indicates that the frequency of the most intense storms and associated storm surges or coastal floods is more likely than not to increase by more than +10% (IPCC 2013, AR5), while the annual frequency of tropical cyclones and associated storm surges or coastal floods are projected to decrease or remain relatively unchanged for the North Atlantic.

This suggests no major change in the frequency of hurricanes and associated storm surges or coastal floods in North Atlantic region comprising US Virgin Islands. The model, however, that sea level rise is projected to increase by small magnitude of 0.35 m over the projected for the 2040s relative to the 1960-1990 baseline. These projections have implications for the USACE's SLOSH (Sea, Lake, and Overland Surges from Hurricanes) computer model (developed by the National Weather Service) that was utilized for this study and could increase the expected surge levels in Table 4.7 above.

Such parameters can be used by the USACE and NWS to understand the potential impact of climate change on coastal inundation levels and magnitude (Table 4.7).

As indicated in the 2011 plan, storm surge inundates coastal areas, washes out dunes, causes backwater flooding in rivers, and can flood streets and buildings in coastal communities. The biggest impact coastal flooding has is the wearing away or eroding of coastal land, which is commonly described as **coastal erosion**. While erosion is considered a function of larger processes of gradual shoreline change, which includes erosion and accretion, it is tied in the US Virgin Islands to hurricane events. This is particularly true in the short-term, where storms can erode a shoreline that may, over the long-term, be accreting.

- Erosion results when more sediment is lost along a particular shoreline than is re-deposited by the water body.
- Accretion results when more sediment is deposited along a particular shoreline than is lost.

Over a long-term period (years), a shoreline is considered to be either eroding or accreting or stable. It is very difficult to measure erosion as a rate, with respect to either a linear retreat (i.e., feet of shoreline recession per year) or volumetric loss (i.e., cubic yards of eroded sediment per linear foot of shoreline frontage per year). This is primarily due to the fact that erosion rates are not uniform, and vary over time at any single location.

Nature of the Hazard

Coastal flooding in the US Virgin Islands is common and associated with low-pressure systems, including tropical storms and hurricanes. In the limited shoreline areas of the US Virgin Islands coastline that slopes gradually inland, the coastal areas are also vulnerable to large coastal sea swells generated by winter storms over the Atlantic Ocean. Rising storm surge levels are a function of wind, atmospheric pressure, tide, waves, and/or swell. Coastal topography and immediate offshore bathymetry (sea bottom contours) directly affect the extent of coastal flooding.

Shoreline changes, on the other hand, are the result of both natural forces and human activities, such as sand mining and beach construction. Environmental awareness has been slowly growing. Hurricane events, such as Hurricane Hugo, Marilyn and Lenny, have illustrated the vulnerability of the US Virgin Islands' beaches. High waves and tides and ocean currents accompanying these storms, are the most significant forces affecting erosion in the US Virgin Islands. Their turbulent energy stirs up and moves the beach sand, eroding the coastline.

Hazard Location, Extent and Distribution

Figure 4.13, 4.14, and 4.15 illustrate the geographic coverage of coastal flooding on the three major islands. The high winds literally pile the water up to create storm surges. The coastal hazard mapping was developed for the USACE using the SLOSH (Sea, Lake, and Overland Surges from Hurricanes) computer model and indicates that the following areas are most susceptible to storm surge on an island by island basis:

- **St. Croix** – Events like Hurricane Hugo were major disaster events due to high winds. However, historically, storm surge has probably been associated with more fatalities. On St. Croix, Christiansted and Frederiksted are located such that it would take an improbable strike to generate significant water threats. Nevertheless, they are at high risk from storm surge if hurricane forces are aggravated by severe wave conditions. Increased industrial and commercial construction in coastal areas has resulted in the removal of coastal vegetation such as mangroves and grasses which have increased vulnerability to coastal flooding.

- **St. John** – Cruz Bay is at risk to storm surges and any waterfront developments along the coastline that could be affected by a surge up to a maximum of 12 feet in elevation above mean sea level.
- **St. Thomas** – In terms of specific locations, Charlotte Amalie and Red Hook are most vulnerable from increased water heights along with much of the shoreline development between those two locations. Although strong storm surges from the south or west are much less frequent, the marinas and large waterfront developments along St. Thomas' south coast would be severely impacted by a large storm from that direction. There are two very large school facilities (Charlotte Amalie High School and Eudora Kean Gymnasium at Red Hook) that offer considerable safe refuge from storm surge. One of their favorable aspects is that they can be accessed by walking.

In addition to Hurricanes, swell waves that are experienced in the US Virgin Islands between the months of October and April may have an impact on USVI shorelines. The storms are caused by intense mid-latitude storms in the North Atlantic and travel thousands of kilometers south to affect the west, north and east coasts of the islands.

<u>FIGURE 4.13</u> ***Coastal Flooding Hazard Map, St. Thomas***

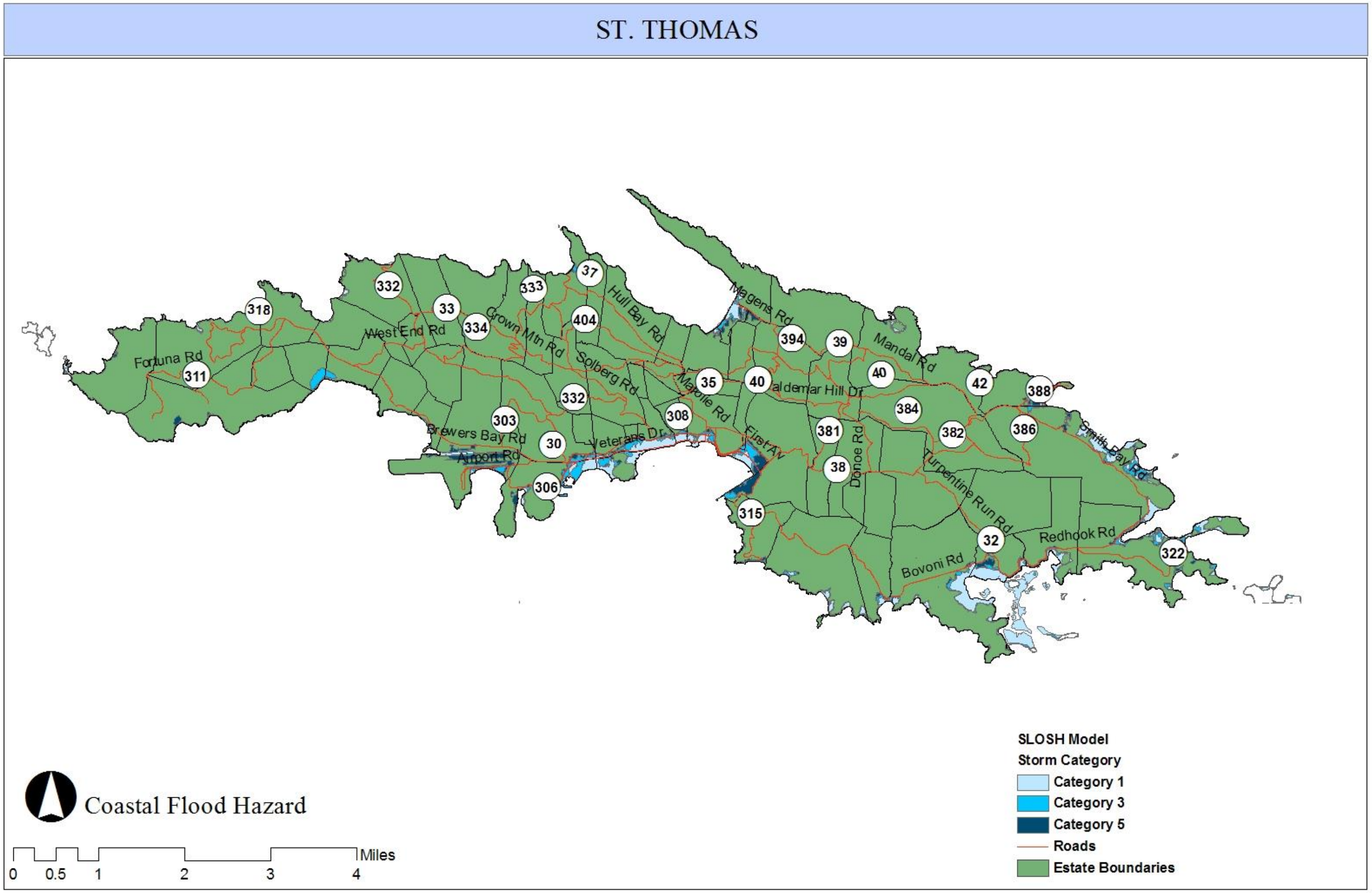


FIGURE 4.14 ***Coastal Flooding Hazard Map, St. Croix***

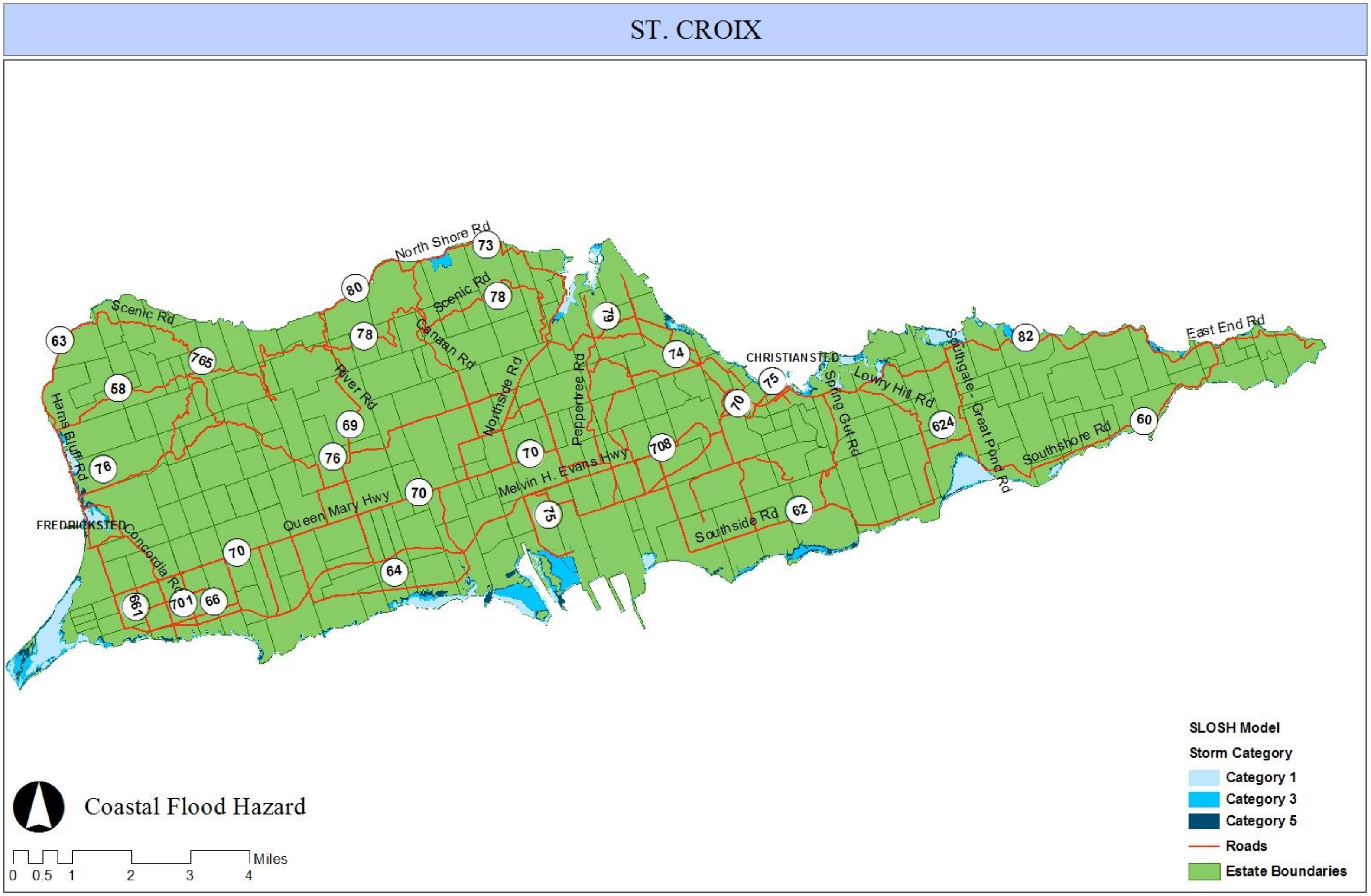
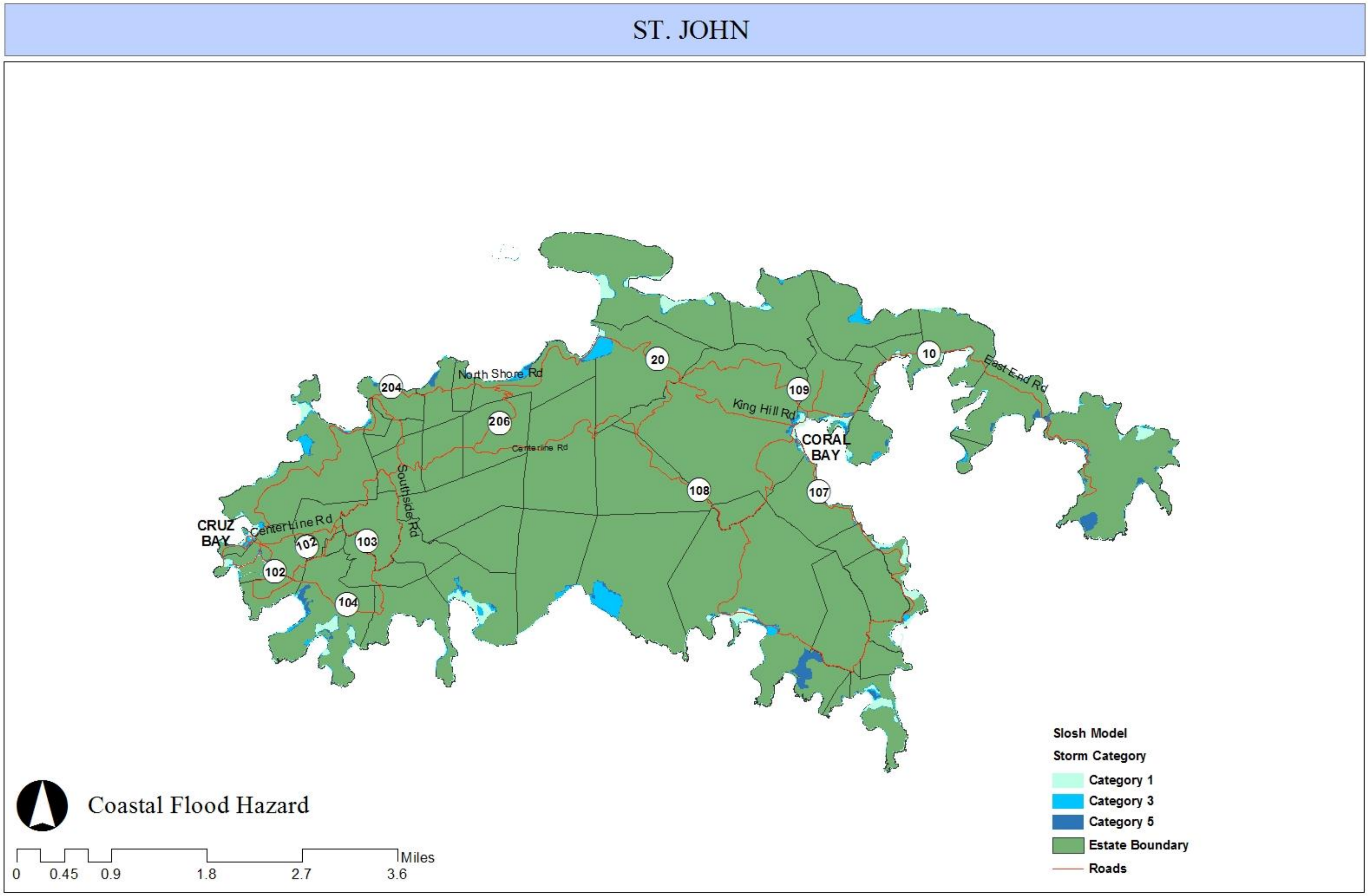


FIGURE 4.15 ***Coastal Flooding Hazard Map, St. John***



Disaster History

Since the last Plan Update (2011), there have not been any major coastal flooding Federal disaster declarations that have caused damage to residential and/or commercial buildings. During the last planning period (2008-2011), Hurricane Earl was the strongest storm to past the islands, but did not have much impact on the shorelines besides washing several boats ashore.

There is limited available information from the US Virgin Islands that isolates coastal flooding from other hazard impacts. One undocumented source lists 15 recorded accounts of storm surges in the local news records from 1867 to 1960. These ranged in magnitude from as little as 1 foot in elevation to the 12 foot mark in 1867. Nearly one half of the occurrences recorded maximum surge elevations of at least 8 feet with commensurate damage.

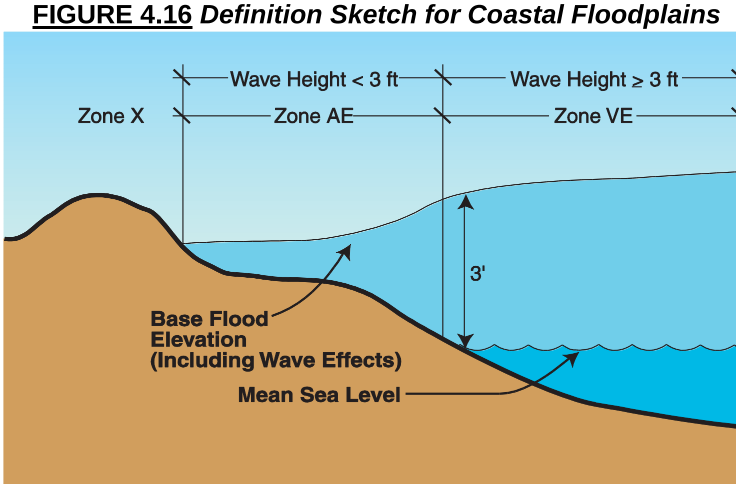
During Hurricane Lenny, tremendous storm surge and wave action affected structures well inland of the coastal high hazard zone (Zone VE) as shown on the FIRMs. The beach and dune systems in the coastal impact areas were destroyed causing increased storm surge inundation levels and wave action in areas previously modeled as being outside the Zone VE.

Between September 16-21, 2010, large, long-period northeast and then north swells of 9 to 13 feet generated by Hurricane Igor began affecting the U.S. Virgin Islands. These long period swells produced very large breaking waves of 15 to 20 feet or higher along local reefs, beaches, and shoals of the local islands. The swells produced minor coastal flooding, beach erosion, and minor structural damage. There was one reported drowning near the Carambola Beach Resort, 2 miles northeast of Christiansted, Saint Croix.

Climate Variability, Hazard Frequency and Magnitude

Much like riverine flooding, predictive modeling has been used by FEMA to create NFIP mapping that reflects the 1% recurrence interval events for storm surge or coastal flooding.

FIGURE 4.16 ***Definition Sketch for Coastal Floodplains***



Source: Understanding Your Risks – FEMA Publication 386-2, Page 2-24

While the “100-year floodplain” for inland and coastal purposes is usually referred to as the “A” zone, there is an additional designation in coastal areas, a “V” or “VE” zone that is the area subject to the 1% recurrence interval flood and in areas where the flood waters create waves that are 3 ft. or greater in height, are anticipated to be moving with velocity and associated forces. The velocity and force of the water make storm surges even more destructive than riverine flooding.

In low-lying coastal areas, such as estuaries, wetlands and mangroves, storm surge can cause problematic saltwater intrusion into freshwater systems. As rising water levels submerge low-lying portions of the lands, it has the potential disrupt sensitive ecosystems and potential diminish critical habitat for larval fish, natural sinks for sediments and pollutants, natural storage for floodwaters, and a cherished aesthetic quality of coastal regions (Incorporating Sea Level Change Scenarios at the Local Level, NOAA 2012).

However, to be consistent with the USACE SLOSH Model that depicts coastal hazard areas for Category 1, 3, and 5 hurricane events. There is an estimated 5% chance for the Territory to experience a Category 3 hurricane each year and the estimated annual probability of experiencing a Category 5 event is less than one percent a year.

Data Sources, Models and Methodologies

Information for the development of the Coastal Flooding Risk Assessment came from a variety of sources, including:

Base Data (Coastal Flooding)

- USACE SLOSH Model for Categories 1, 3, and 5 storms.
- USACE Digital Terrain Model

Coastal Flood Hazard Assessment and Determination

- USACE inundation maps derived from a SLOSH (Sea, Lake, and Overland Surges from Hurricanes) model computes storm were identified as the most comprehensive coastal flood polygon data for the US Virgin Islands.
- Surge inundation polygons were developed for three categories of hurricanes as defined by the Saffir-Simpson scale (Categories 1, 3, and 5).
- GIS overlay techniques were utilized to identify structures in the coastal flood polygons.
- Flood depths were estimated for each estate affected by coastal flooding by overlaying the Q3 flood zone data on a digital elevation model.
- NOAA Coastal service Center, Incorporating Sea Level Change Scenarios at the Local Level, NOAA 2012

Inventory Data (Assets)

- General Building Stock: Office of the Lt. Governor, Office of the Tax Assessor, Computer Mass Appraisal System Database and GIS Parcel Maps
- Critical Facilities and Infrastructure: VI Department of Property and Procurement, VITEMA

4.4.6 HURRICANE WINDS

Hazard Description

Hurricanes and tropical storms are large-scale systems of severe thunderstorms that develop over tropical or subtropical waters and have a defined, organized circulation. Hurricanes have a maximum sustained (meaning 1-minute average) surface wind speed of at least 74 mph; tropical storms have wind speeds of 39 mph to 74 mph.

Hurricanes and tropical cyclones get their energy from warm waters and lose strength as the system moves inland. Hurricanes and tropical storms can bring severe winds, inland riverine flooding, flooding in coastal areas, storm surges, coastal erosion, extreme rainfall, thunderstorms, lightning, and tornadoes. Hurricanes and tropical storms typically have enough moisture to cause extensive flooding throughout the Territory, often to the 100- or 500-year flood elevations. However, this subsection is focused on Hurricane Winds; flooding effects of hurricanes and tropical storms are covered in Sections 4.4.4 and 4.4.5 – Riverine and Coastal Flooding, respectively.

Hurricane magnitude is measured on the Saffir-Simpson hurricane scale, shown in Table 4.8, which categorizes hurricane magnitude by wind speeds and storm surge above normal sea levels.

TABLE 4.8 ***Saffir-Simpson Hurricane Scale***

Category	Wind Speed	Expected Damage
1	74–95 mph	**Minimal**: Damage primarily to shrubbery and trees; unanchored mobile homes damaged; some damaged signs; no real damage to structures.
2	96–110 mph	**Moderate**: Some trees toppled; some roof coverings damaged; major damage to mobile homes.
3	111–130 mph	**Extensive**: Large trees toppled; some structural damage to roofs; mobile homes destroyed; structural damage to small homes and utility buildings.
4	131–155 mph	**Extreme**: Extensive damage to roofs, windows, and doors; roof systems on small buildings completely fail; some curtain walls fail.
5	> 155 mph	**Catastrophic**: Considerable and widespread roof damage; severe window and door damage; extensive glass failures; entire buildings may fail.

Nature of the Hazard

The US Virgin Islands of the Caribbean are among the most hurricane-prone locations in the world. While the Atlantic Basin hurricane season officially extends from June 1 to November 30, over the last 117 years, the US Virgin Islands has experienced hurricanes no earlier than July 7th (unnamed storm in 1901) and as late as November 23rd (Hurricane Lenny in 1999).

In 2008, Hurricane Omar (2008) passed over the US Virgin Islands and caused damages to critical facilities and infrastructure that was estimated to be $2.2 million; while Hurricane Earl (2010), a much bigger storm, passed north of the Territory and caused $2.1 million in estimated damages. The Territory also experienced severe storms, flooding, rockslides, and mudslides associated with Tropical Storm Tomas in late November 2010.

The peak of activity occurs in September with half of the number of average annual storms occurring in that month.

Hazard Location, Extent and Distribution

One of the most serious components of hurricanes is high winds. Because of the extensive size of a catastrophic hurricane a storm need not pass directly over the Territory to cause severe damage. A hurricane passing within close proximity can also cause major damage to property and even loss of life. Due to the relatively small geographical size of the Territory, any storm passing within a radius of 100 miles is a potential for property loss. Within the past three years four Tropical Storm systems passed within this radius. Accompanying coastal and riverine flooding have a strong spatial context and are addressed in the later sections of this Plan.

Essentially there are no areas of the US Virgin Islands that are free from hurricane force winds. The coastal and low lying areas experience the first effects of damaging winds, but due to the hilly and mountainous nature of the Territory, winds are funneled in gullies and passes between mountainous terrain seeking to traverse the mountains and ridges, and are often compacted and intensified causing damage to structures at higher elevations. While the entire territory is exposed to hurricane winds, there are variations in vulnerability primarily due to the number of properties and type of construction. The newer construction structures that have been built to codes are less vulnerable than the older structures. Another factor is the type of construction – i.e. wood frame structures – that are more susceptible to damages than reinforced concrete. The differences in vulnerability for each island in the Territory are highlighted in Section 4.5 below.

Disaster History

For this Plan Update, there have been no federal disaster declarations. Since the 2005 Plan, Tropical Storm Dean (8/17/07) traversed south of the Virgin Islands. Minimal damage was sustained and limited for the most part to downed trees and coastal road erosion. Between 1887 and 1989, 36 hurricanes passed within 125 miles of the US Virgin Islands (USACE *Hurricane Evacuation Study*, 1994).

Of the 22 most deadliest, costliest, and most intense hurricanes to strike outlying US territories and the State of Hawaii over the past 100 years, 7 have struck the US Virgin Islands including:

- San Ciprian (1932). US Virgin Islands and Puerto Rico (PR). Damages estimated at $494 million,
- San Mateo (1949). St Croix. Damages unknown,
- Donna (1960). St. Thomas and PR. Damages unknown,
- Hugo (1989). US Virgin Islands and PR. Damages estimated at $1.4 billion,
- Marilyn (1995). US Virgin Islands and PR. Damages estimated at $1.8 billion,

- Georges (1998). US Virgin Islands and PR. Damages estimated at $1.9 billion, and
- Lenny (1999). US Virgin Islands and PR. Damages estimated at $342 million.

Note: Damage estimates include Puerto Rico and were adjusted for inflation (NOAA 2004); damages for Omar and Earl are from Preliminary Damage Assessment Reports.

In 2004 four major storms passed through the Caribbean causing varying levels of damage with one – Tropical Storm Jeanne – resulting in a presidential disaster declaration. Tropical Storm Jeanne affected the Territory with high winds and torrential rains inflicting a total of $6.4 million in damage, mostly to the infrastructure, with downed power lines and damaged or debris filled roadways. Most damage was caused on St. Croix, but all three islands of the Territory experienced damage and received excessive rainfall and record flood levels. The damages associated with the Omar 2008 ($2.2 million) and Earl 2010 ($2.1 million) are minor in comparison.

The majority of presidential declarations in the US Virgin Islands result from hurricanes. A brief description of some recent hurricanes that have impacted the US Virgin Islands follows:

- **Hurricane Klaus** (October 1984). Hurricane Klaus traversed the islands leaving moderate damage to roads and bridges, and heavily damaging the Fredericksted Pier in St. Croix. The most significant hazard event was flooding caused by the heavy rains that accompanied the storm.
- **Hurricane Hugo** (September 1989). Hugo passed directly over the Island of St. Croix on a west northwest track at speeds of 3 - 10 mph. Hugo was a destructive Category 5 hurricane when it impacted St. Croix. As a result, St. Croix suffered damages of catastrophic proportion. The center of the storm passed west of St. Thomas, but still inflicted severe damage. St. Thomas received substantial damage to public and private facilities.
- **Hurricane Marilyn**[7] (September 1995). This time, St. Thomas bore the brunt of this large hurricane; the eye of the hurricane was more than 20 miles across. Hurricane Marilyn was at Category 1 strength, and intensified to nearly Category 3 strength by the time it reached the U.S. Virgin Islands. Marilyn caused 10 deaths and left thousands homeless. Marilyn damaged or destroyed nearly all 12,000 homes on St. Thomas and another 5,000 on St. Croix. Damage to commercial and residential roofs was extensive. The damages to the WAPA's electric distribution system alone were estimated at $44 million. The storm also destroyed warehoused food stocks and damaged the only hospital on St. Thomas.
- **Hurricane Lenny** (November 1999). An unusual hurricane that tracked across the Caribbean from the west. Lenny made landfall on the western coast of the St. Croix, causing extensive storm surge damages along it's coastline. Lenny's maximum winds reached 150 mph as it approached the US Virgin Islands.
- **Hurricane Omar** (October 2008). Hurricane Omar weakened from a Category 3 to a Category 1 storm as it quickly moved over the US Virgin Islands. A last minute shift to the east spared St.

[7] Hurricane Marilyn was at Category 1 strength, and intensified to nearly Category 3 strength by the time it reached the U.S. Virgin Islands.

Croix, the most populated of the U.S. Virgin Islands, which received just a glancing blow from the weaker side of the system. Omar knocked down trees, caused some flooding and minor mudslides.

- **Hurricane Earl** (August 2010). Hurricane Earl, a Category 3 storm, passed near or over the northernmost part of the U.S. Virgin Islands. Hurricane conditions spread across the northern U.S. Virgin Islands to Culebra and Puerto Rico. The eye of Earl passed just north of the British Virgin Islands, and its closest point of approach to the U.S. Virgin islands was around 3 pm on the 30th when it was located about 60 miles northeast of St. Thomas. By 5 pm Earl strengthened into a category 4 hurricane, with maximum winds of around 135 mph while it was moving away from the Virgin Islands.

It is important to note that prior to Hurricane Hugo, the last hurricane with winds of Category 3 or greater occurred 73 years earlier in 1916. During the period from 1916 to 1989, dozens of milder tropical storms and hurricanes came in close proximity or made landfall but none caused the damages associated with Hugo and Marilyn.

Climate Variability, Hazard Frequency and Magnitude

A 1994 study produced for the US Virgin Islands Water and Authority (WAPA)[8] used the available historical record to determine approximate return periods (probability of frequency) for hurricanes of different categories (see Table 4.8: Saffir-Simpson Hurricane Scale). For example, the Territory could expect a Category 3 hurricane once every 20 years as shown on the matrix below. The results are shown in Table 4.9

TABLE 4.9 ***Frequency of Hurricanes Passing By or Through the US Virgin Islands***

Intensity	Average Return Period
Category 3	20 years
Category 4	50 years
Category 5	120 years
Source: US Virgin Islands WAPA 1994	

[8] The study went on to note: "*that the above estimated return periods are for hurricanes with the corresponding intensity level passing by or through the islands and are not the return periods for a direct hit on the islands. Moreover, because the prevailing hurricane direction in this region is from east to west, the chance of a hurricane traveling north and hitting St. Croix first and then St. Thomas and St. John is very small. Thus, the worst possible realistic scenario is for a hurricane track to be located between St. Croix and St. Thomas/St. John having an east/southeast to west/northwest direction.*"

The Atlantic Oceanographic and Meteorological Laboratory's FAQ (Frequently Asked Questions) web site[9] indicates that there is an estimated 42% chance each year of experiencing a strike by a tropical storm or hurricane in the US Virgin Islands. These probabilities were developed from recorded data for the years 1944 to 1999 when a storm or hurricane was within about 100 miles (165 km) of a particular location.

The structure and areal extent of the wind field in tropical cyclones is largely independent of intensity storms and play an important role on potential impacts. With the use of satellite imagery and other instruments, intensity measurements have become more accurate, and as a result, the recorded intensities of wind storms in the Atlantic have been increasing. However, the IPCC Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5, 2013) indicates that the frequency of the most intense storms is more likely than not to increase by more than +10% (IPCC 2013, AR5), while the annual frequency of tropical cyclones are projected to decrease or remain relatively unchanged for the North Atlantic. This suggests no major change in the frequency of hurricanes in North Atlantic region comprising USVI and that wind speeds are expected to actually decrease by very small magnitude of 0.25 m/s (0.559 mph) over the projected for the 2040s relative to the 1960-1990 baseline.

The design wind speed for the USVI in ASCE 7-05 is 145 mph (3-second peak gust) may actually decline marginally due to climate change projects, if it were indeed related to a return interval. This is equivalent to a Category 3 hurricane on the Saffir Simpson scale. There is an estimated 5% chance of experiencing a Category 3 hurricane each year.

Data Sources, Models and Methodologies

Information for the development of the Hurricane Risk Assessment came from a variety of sources, including:

Base Data

- NOAA National Climatic Data Center.
- American Society of Civil Engineers (ASCE) 7-05 Design Wind Speeds.
- *"Estimation of Potential Hurricane and Earthquake Losses to Water and Power Facilities"* (EQE international, 1994.)
- IPCC AR4, 2007, The IPCC Fourth Assessment Report of the Intergovernmental Panel on Climate Change
- IPCC AR5, 2014, IPCC Fifth Assessment Report of the Intergovernmental Panel on Climate Change

Hurricane Hazard Assessment and Determination

- The American Society of Civil Engineers (ASCE) 7-05 Design Wind Speed maps were the primary data input for the wind hazard model as probabilistic data were not readily available. The ASCE Design Wind Speeds take into account historical events such as hurricanes and tropical storms.

[9] http://www.aoml.noaa.gov/hrd/tcfaq/G11.html

The design wind speed in ASCE 7-05[10] for the US Virgin Islands is 145 Mph. In this study design wind speed refers to the sustained wind velocity that structures should be constructed to withstand without suffering catastrophic or total damage. The maps developed show the frequency and paths of hurricanes with winds of Category 4 or above.

Inventory Data (Assets)

- General Building Stock: Office of the Lt. Governor, Office of the Tax Assessor, Computer Mass Appraisal System Database and GIS Parcel Maps
- Critical Facilities and Infrastructure: VI Department of Property and Procurement, VITEMA

[10]Note that ASCE wind speeds are 3-second peak gusts

4.4.7 RAIN-INDUCED LANDSLIDE

Hazard Description

Landslides are described as downward movement of a slope and materials under the force of gravity. The term landslide includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows. Landslides are influenced by human activity (construction of buildings and highways) and natural factors (soils, precipitation, and topography).

Landslides occur when masses of rock, earth, or debris move down a slope. Therefore, gravity acting on an overly steep slope is the primary cause of a landslide. They are triggered by storms, earthquakes (not addressed in this analysis), and by human modifications to the landscape. Wildfires can increase the probability of rain-induced landslides occurring.

Mudflows (or debris flows) are flows of rock, earth, and other debris saturated with water. They develop when water rapidly accumulates in the ground, such as during periods of prolonged heavy rainfall, changing the earth into a flowing river of mud. Mudslides can flow rapidly down slopes or through channels and can strike with little or no warning at tremendous speeds. Other types of landslides include: rock slides, slumps, mudslides, and earthflows. All of these differ in terms of content and flow. In the USVI, hydrologic factors (rain, high water table, little or no ground cover) and human factors (development activities such as cutting and filling along roads and removal of forest vegetation) exacerbate the effects of landslides.

Nature of the Hazard

It is very hard to evaluate the location or geographic distribution of landslides across the U.S. Virgin Islands as there is not a historical record from which to reference the incidences of landslides in the Territory. Landslides occur because of a variety of factors in the Virgin Islands and are dues to such factors as topography, slope, climate, and soils. Locations at risk from landslides include areas with one or more of the following conditions:

- On or close to steep hills;
- Steep road-cuts or excavations;
- Existing landslides or places of known historic landslides (such sites often have tilted power lines, trees tilted in various directions, cracks in the ground, and irregular-surfaced ground);
- Steep areas where surface runoff is channeled, such as below culverts, V -shaped valleys, and steep intermittent stream channels; and
- Areas where slopes are not maintained or are altered by the property owners (clear-cutting).

Although spatial extent of landslides is hard to determine, human impacts have substantial effect on the potential for landslide failures. Proper planning and geotechnical engineering can be exercised to reduce the threat to people, property, and infrastructure.

Hazard Location, Extent and Distribution

Figure 4.17, 4.18, and 4.19 illustrate the geographic coverage of areas susceptible to rain-induced landslides on the three major islands. The landslide susceptibility maps were developed as part of this project through a constraint mapping methodology that combined elevation, slope, soils and hydrologic units in a Geographic Information System computer model. The following areas are most susceptible to rain-induced landslides on an island by island basis:

- St. John - Events like the severe rainfall experience in November 2010 triggered landslides along portions Centerline road between Cruz Bay and Coral Bay. Nine areas along Centerline Road were blocked and another major landslide in the Bordeaux Mountain area also blocked a major road.
- St. Thomas. The mountain areas, particularly northern facing slopes of the island are the most susceptible to the landslides. Areas in Dorothea and St. Peter Mountain road are especially prone to this hazard. These areas experienced washouts during the recent heavy rainfall events (November/December, 2010). Higher elevations on southern facing slopes, particularly in the area of Crown Mountain are also susceptible to landslides. On Crown Mountain road, a deluge of water shut down the road. A major landslide just beyond the intersection of Crown Mountain and Scott Free roads occurred, along with other smaller landslides. This left Crown Mountain Road impassable at one point.
- St. Croix. The greater variations of rainfall on St. Croix make the landslide hazard more dispersed. The northwestern part of the island receives the greatest amount of rainfall, and as a result, the northern slopes of the mountainous area are highly susceptible to landslides. There are some central areas with steep slopes in the south central area of the island (outside Christiansted) that are also susceptible to landslides. Eastern portions of the island are less susceptible to landslides, particularly lower portions of watershed basins.

Disaster History

Almost no published literature on the occurrence of landslides exists for the Virgin Islands[11].
A reconnaissance of landslide potential on St. Thomas (Brabb, 1984) indicates that earthflows, debris slides, and individual boulders are recognized landslide types on St. Thomas. Debris flows are not documented or reported as occurring on this island.

11 http://isis.uwimona.edu.jm/uds/Land_US Virgin Islands.html

- The largest landslide documented on St. Thomas is 60 meters long and 60 meters wide. It was mapped in an area about 1.5 kilometers north of Charlotte Amalie in 1979.

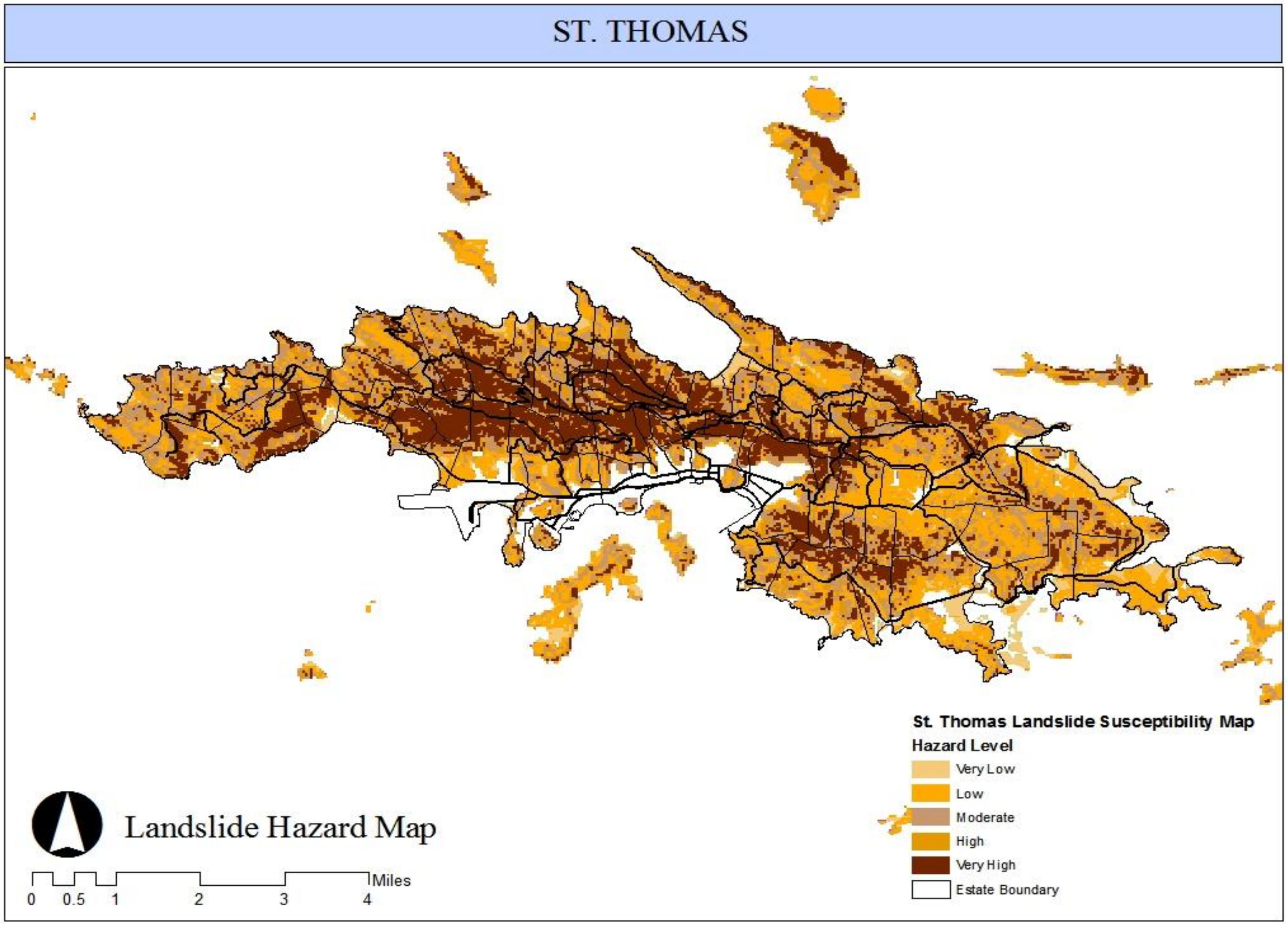
- On April 18, 1983, a storm drenched Dorothea Bay with nearly 400 millimeters of rain in 14 hours. In addition to extensive flooding, this storm event produced a number of landslides. Two earthflows developed in weathered colluvium (unconsolidated materials of various sizes). These are small features about 30 meters long and 30 meters wide. Very small debris slides occurred in colluvium exposed at the top of some road cuts. Boulders temporarily blocked several roads. One boulder which was 6 meters in maximum diameter traveled 10 meters downslope before stopping next to and above a house (Brabb, 1984).

- St. John (2010) nine (9) landslides occurred along portions Centerline road between Cruz Bay and Coral Bay.

- St. John (2010) another major landslide in the Bordeaux Mountain area also blocked a major road.

- St. Thomas. (2010) a major landslide just beyond the intersection of Crown Mountain and Scott Free roads.

FIGURE 4.17 ***Landslide Hazard Map, St. Thomas***



<u>FIGURE 4.18</u> ***Landslide Hazard Map, St. Croix***

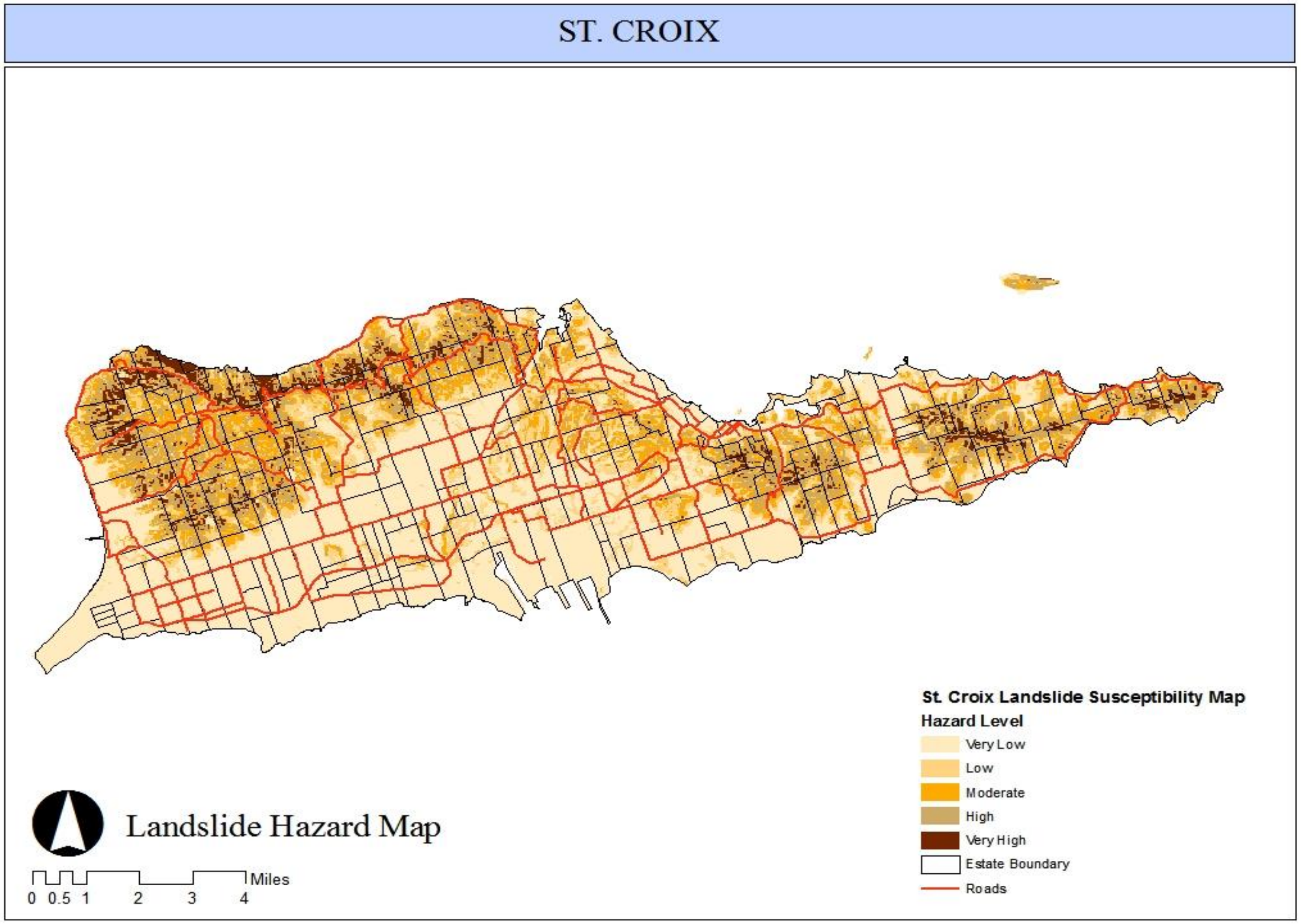
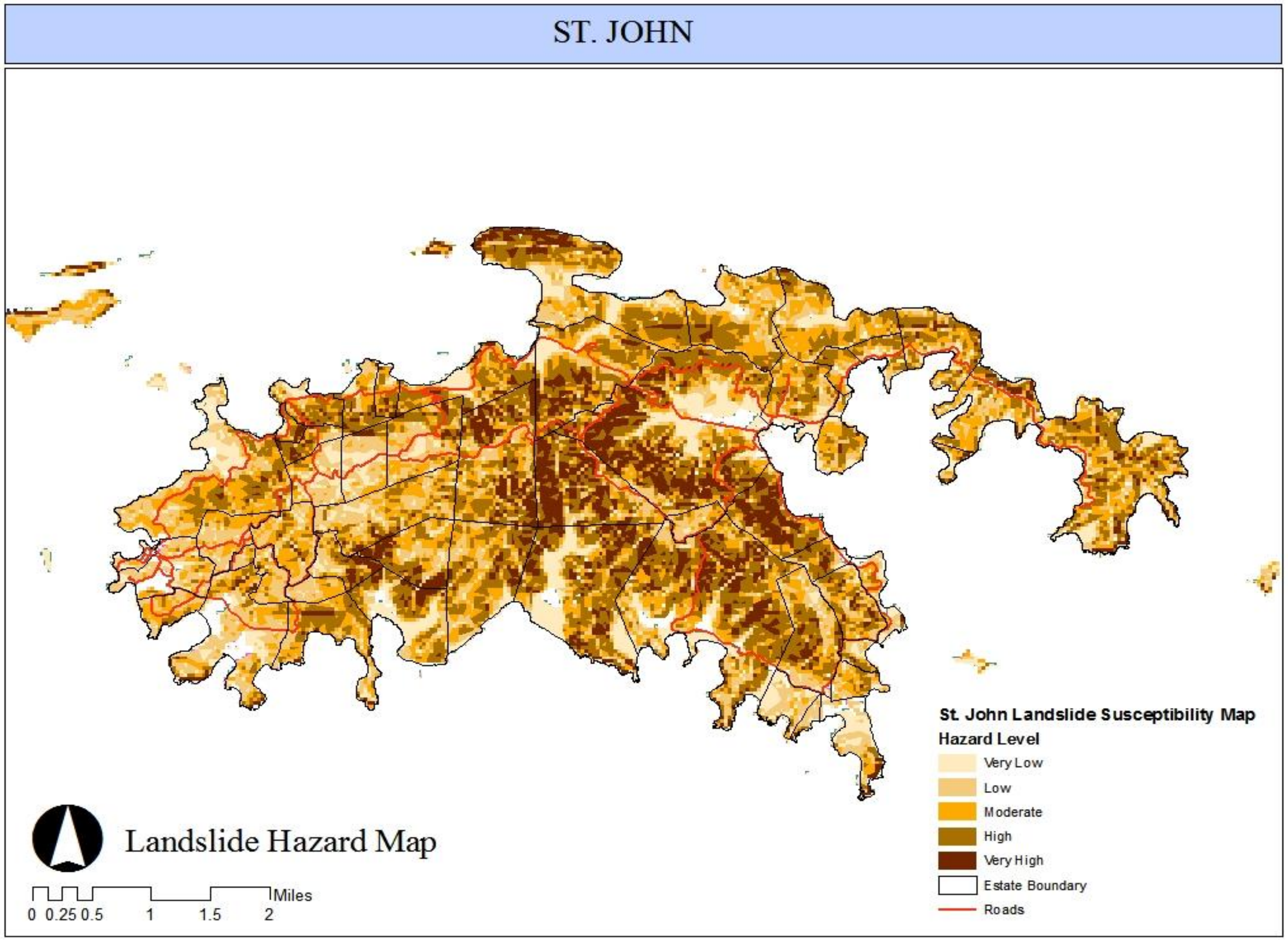


FIGURE 4.19 ***Landslide Hazard Map, St. John***



Climate Variability, Hazard Frequency and Magnitude

There is a general lack of understanding and information available to determine the frequency and/or magnitude of landslides in the US Virgin Islands. If we tied the incidence of rain-induced landslides to heavy rainfall events, it appears landslide activity is limited in magnitude as the economic data has not been captured for documenting the impact of each landslide. Based on the limited data, US Virgin Islands (territory-wide) can expect at least one (1) landslide event per year.

The implications of climate variability on the landslide hazard is tied to the intensity of past climate data so as to facilitate an understanding of whether data derived from regional climate models will increase the potential for landslide events in the study area. The hazard model that was used took into consideration precipitation, which indicates that landslide events are triggered by intense precipitation. Therefore, based on the IPCC projections which predict an increase intense precipitation events, the impact f climate change will increase the possibility of experiencing landslides will increase.

To incorporate climate change into future landslide hazard models will necessitate making use of detailed historic records.

Data Sources, Models and Methodologies

Base Data

- (2010): Average Annual Rainfall 1971 -2000, Oregon State University (OSU) Spatial Climate Analysis Service.
- USACE Digital Terrain Model (2008)
- Hydrologic Units for USVI (2002) U.S. Geological Survey in cooperation with the U.S. Department of Agriculture, Natural Resources Conservation Service

Hazard Assessment and Determination

- USVI Soil Survey, US Department of Agriculture, Natural Resources Conservation
- Brabb, E.E. 1984. Landslide potential on St. Thomas, Virgin Islands, p.97-102. U.S. Geological Survey Open –File Report 84-762

Inventory Data (Assets)

- General Building Stock: Office of the Lt. Governor, Office of the Tax Assessor, Computer Mass Appraisal System Database and GIS Parcel Maps
- Critical Facilities and Infrastructure: VI Department of Property and Procurement, VITEMA

4.4.8 TSUNAMI

Hazard Description

A tsunami is a series of long waves generated in the ocean by a sudden displacement of a large volume of water. Underwater earthquakes, landslides, volcanic eruptions, meteor impacts, or onshore slope failures can cause this displacement. Most tsunamis originate in the Pacific Ocean associated with the high level of seismic activity present.

Tsunami waves can travel at speeds averaging 450 to 600 miles per hour. As a tsunami nears the coastline, its speed diminishes, its wavelength decreases, and its height increases greatly. Unusual heights have been known to be over 100 feet high. However, waves that are between 10 to 20 feet high can be very destructive and cause many deaths and injuries. An earthquake need not originate in the near proximity to a land mass to be destructive. Simply put, tsunamis are known to have immediate, intermediate and distant ranges. Destructive waves are known to travel over 1000 miles at alarming speeds. Of course, the closer the epicenter of an event to a land mass, the shorter the period of warning and preparation.

After a major earthquake or other tsunami-inducing activity occurs, a tsunami could reach the shore within a few minutes. From the source of the tsunami-generating event, waves travel outward in all directions in ripples. As these waves approach coastal areas, the time between successive wave crests varies from 5 to 90 minutes. The first wave is usually not the largest in the series of waves, nor is it the most significant. One coastal community may experience no damaging waves while another may experience destructive deadly waves. Some low-lying areas could experience severe inland inundation of water and deposition of debris of more than 1,000 feet inland.

Nature of the Hazard

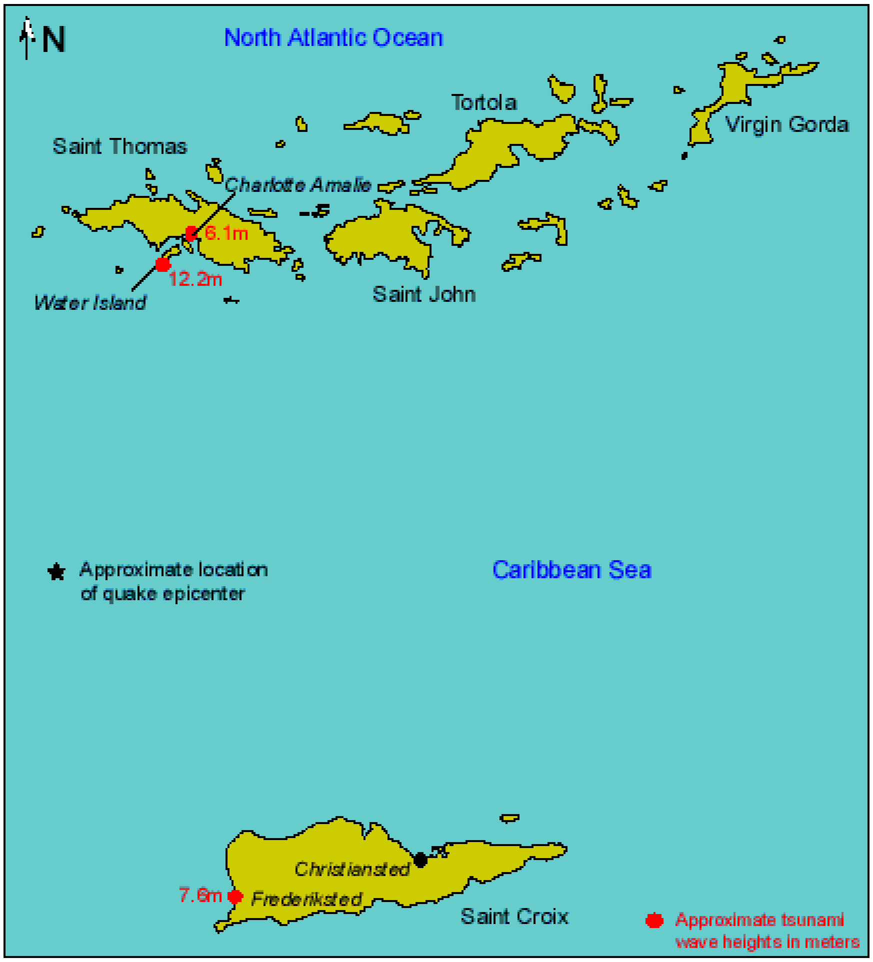
Due to the historical record of earthquakes in the region, it is considered reasonable to expect that tsunamis would be generated as well, and the historic record bears this out (see Disaster History below). It is important to note that the sites for tsunami generation are likely to be very close to the coast and so warning time is very short. Therefore, the types of strategies that will be more effective focus on proper siting of structures as opposed to implementing warning systems.

However, in 2000, the University of Puerto Rico established a tsunami warning system for both Puerto Rico and the U S Virgin Islands. The efforts to strengthen its reliability and effectiveness have increased, especially since the major event in the Pacific Basin in 2004 that affected Indonesia, W Thailand, Sri Lanka, SE India. The warning system has an estimated response time of twenty minutes after an earthquake event. But the close proximity of the Puerto Rican Trench and the Anegada Fault, a devastating tsunami could occur before warning is issued. Researchers estimate that should a strong tsunami occur in the northern Caribbean region, the increase in population within the potentially affected zone, 35,5 million people could be affected by such an event.

Tsunamis had a dramatic impact on the US Virgin Islands, when in 1867, a magnitude 7.5 earthquake occurred in the Anegada Trench. Two tsunami waves struck Charlotte Amalie, ten minutes apart. Both waves struck the harbor as a large recession of water, followed by a bore, which eyewitness accounts describe as a 6 meter wall of water. The waves destroyed many boats anchored in the harbor, leveled the town's iron wharf, and either flooded out or destroyed all buildings located along the waterfront area. The tsunami produced an estimated 2.4 meters of run-up at Charlotte Amalie, and a maximum 75 meters of landward inundation. Frederiksted, in St. Croix was also stuck by two tsunami waves, that same day, although of lesser magnitude, estimated at 7.6 meters high.

Figure 4.20 illustrates the projected epicenter of the 1867 earthquake in relation to St. Thomas and St. Croix.

FIGURE 4.20 ***Projected Epicenter of the 1867 Earthquake***



Hazard Location, Extent and Distribution

Tsunami hazard areas are all low lying, relatively flat coastal areas. Tsunami hazard areas in US Virgin Islands are depicted in Figures 4.21, 4.22 and 4.23. Tsunami impacts will vary in the Virgin Islands. The Tsunami hazard maps have been updated for this Plan Update to be more conservative. They have been developed in accordance national tsunami evacuation planning mapping documentation. The maps have been developed to define an evacuation zone for the US Virgin Island using an 82-foot elevation profile and an inundation of 2 miles from the coast. This evacuation criterion was based on historical events, tsunami modeling results from Puerto Rico and the BVI and the US National Tsunami Hazard Mitigation Program guidelines. This conservative estimate, however, did not consider offshore and near shore coastal topography (not considered in the tsunami hazard map developed in this study), vegetation and level and type of development. High waves will have only a serious impact, however, if the shoreline is low enough to be susceptible to flooding.

On St. Thomas, like St. John, the coastal areas are intensively developed. Charlotte Amalie and Cruz Bay are urbanized and have extensive infrastructure and road networks and are considered the most vulnerable areas to the tsunami hazard. On St. John, waterfront development, particularly port facilities and commercial development on the water such as shopping centers and hotels along the coastline could be affected by a tsunami. Both islands have secondary locations, Red Hook on St. Thomas and Coral Bay on St. John that are vulnerable to a tsunami. Both of these locations have experienced significant development in the past three years creating a potential for considerable property damage and possible loss of life.

In St. Thomas, cruise ships are highly vulnerable to tsunamis. In a recent paper given to the NSF Caribbean Tsunami Workshop, San Juan, March 30-31, 2004, Dr. Roy A. Watlington of the University of the Virgin Islands, indicated that on a three cruise ship day in St. Thomas, between 8:00 and 10:00 am as many as 12,000 tourists and crew may disembark to engage in recreational activities. The preferred activities of visitors, which include swimming at beaches, visits to the Coral World aquarium, sailing and boat sightseeing, keep them confined to tsunami prone coastal areas. Since the business district of Charlotte Amaile is also exposed to a tsunami, those visitors who elect to frequent the many stores, are also at risk. Furthermore, the report cites that several critical facilities are prone to tsunamis. These facilities include Virgin Islands Government offices (legislature, courts, and executive offices), electricity/desalination plants of the Water and Power Authority, the airport, port facilities and several schools.

The physiographic composition of St. Croix is vastly different from the previous two islands. The result is a landscape with much less topographic relief than St. Thomas and St. John. Nevertheless, it has two urban areas, Christiansted and Frederiksted that are particularly exposed to tsunami hazard. The town of Frederiksted suffered major damage from the 1867 tsunami, but not to the extent experienced on St. Thomas. Watlington, 1984 cites that on St. Croix several critical facilities are prone to tsunamis. These facilities include the electricity/desalination plant of the Water and Power Authority, HOVENSA (a large oil refinery), and the airport.

FIGURE 4.21 ***Tsunami Hazard Map, St. Thomas***

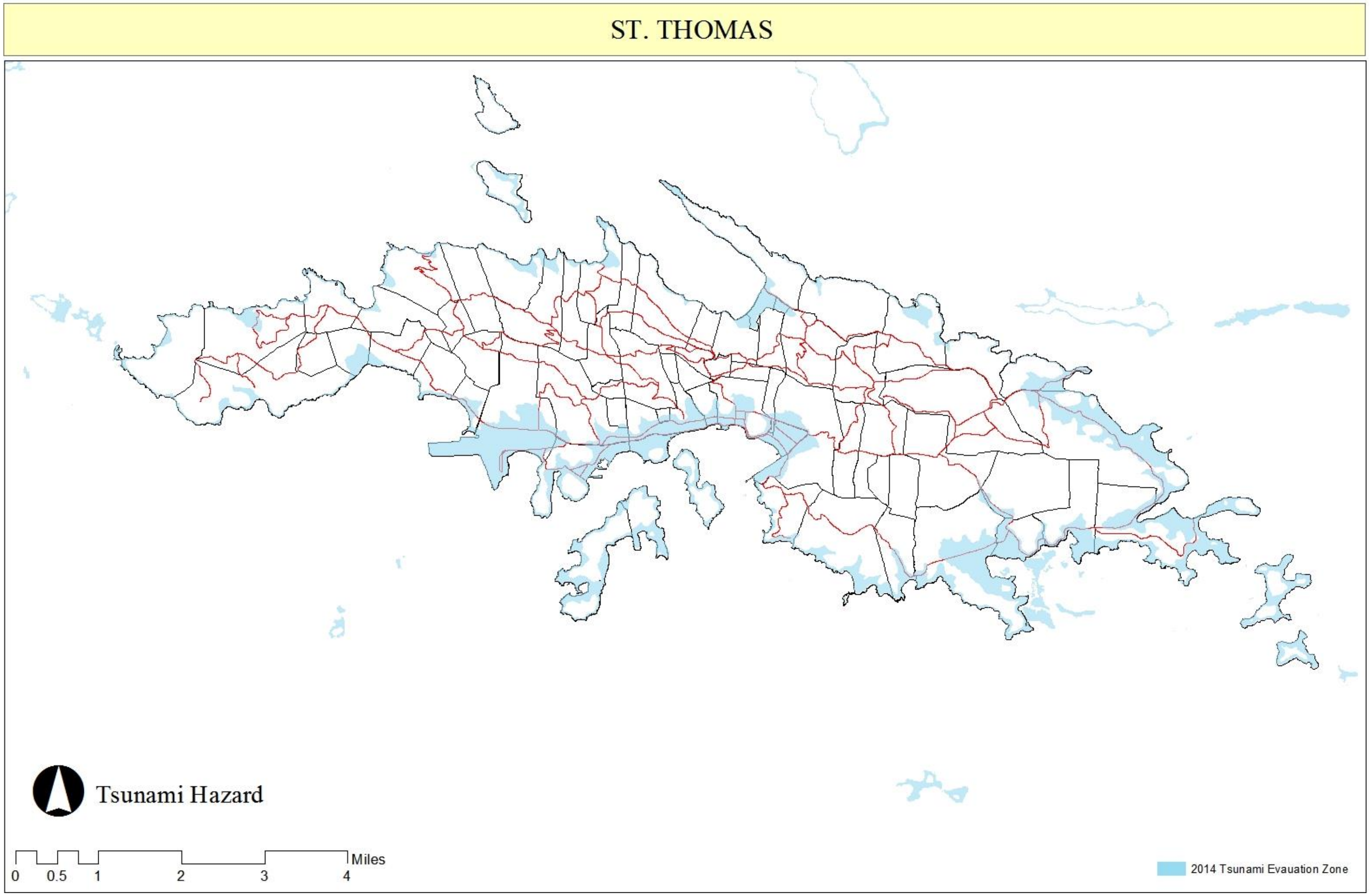


FIGURE 4.22 ***Tsunami Hazard Map, St. Croix***

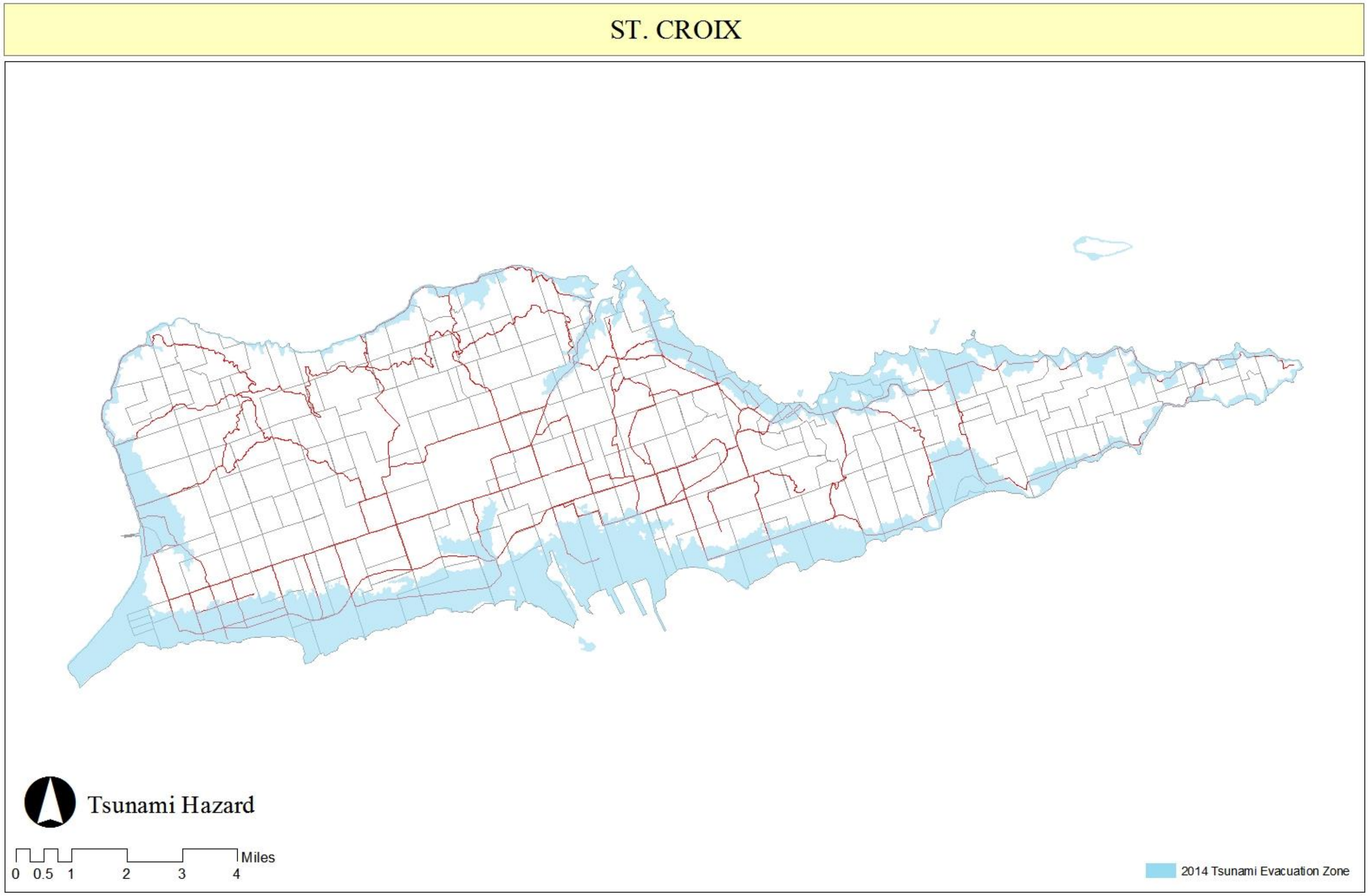
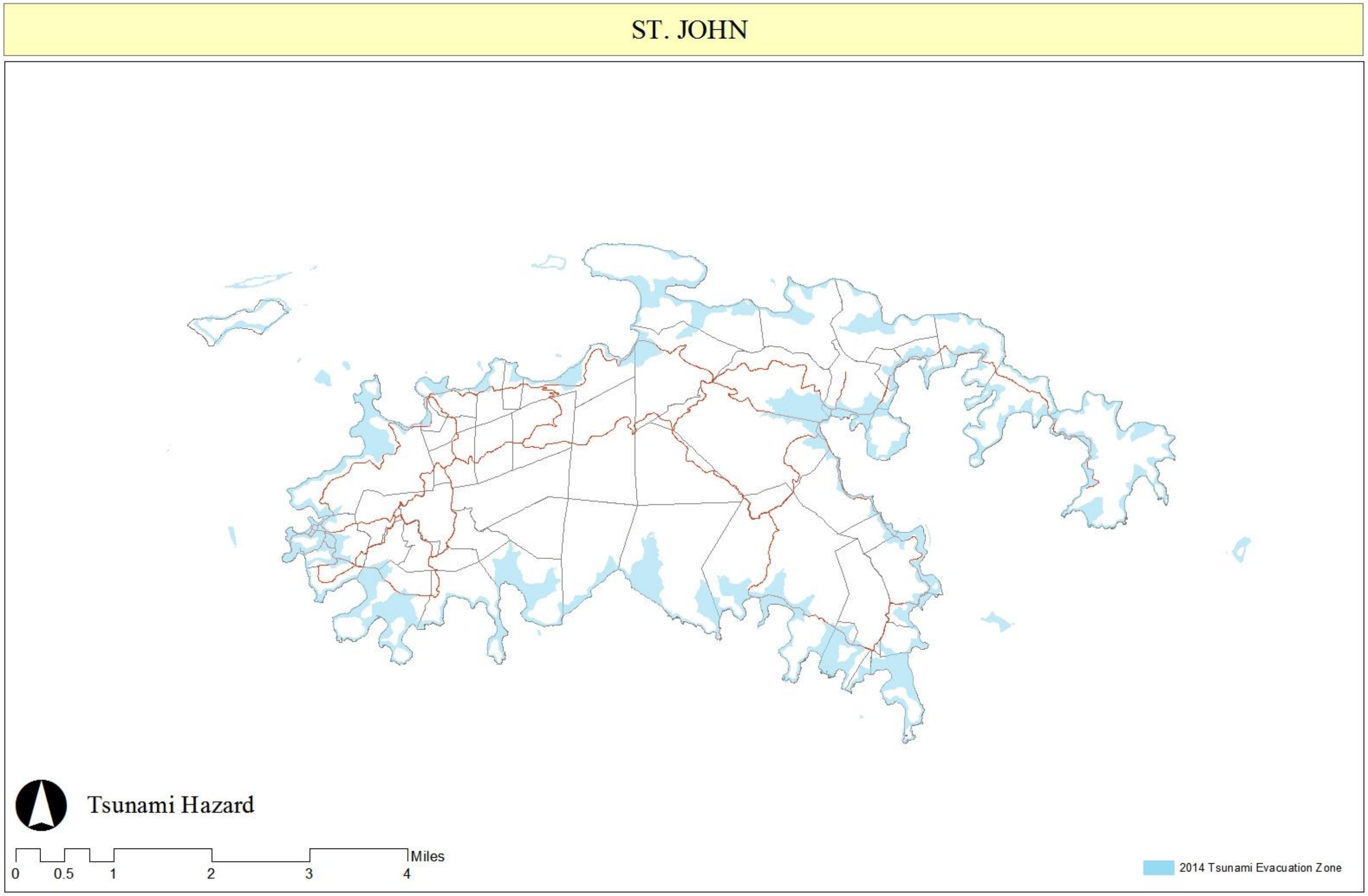


FIGURE 4.23 ***Tsunami Hazard Map, St. John***



Disaster History

Tom Parsons and Eric Geist[12] identify 116 individual observations of tsunami run ups in excess of 0.5 meters since 1530 (Caribbean-wide). Of these events, 14 tsunamis have been reported from Puerto Rico and the Virgin Islands (Lander et al., submitted). 30 tsunamis caused significant damage including reports of as many as 9,600 fatalities, which can be attributed to underwater earthquakes and tsunamis combined. 1,922 deaths are confirmed as being specifically related to tsunamis during the last 150 years. The following are events recorded for the Virgin Islands:

- May 7, 1842. Tsunami hit St. John. Maximum wave height was estimated to be 3 meters.
- Eyewitness reports of the 1868 St. Croix tsunami give a maximum wave height of over 20 feet in Frederiksted.
- A 1918 M 7.5 earthquake resulted in a tsunami that killed at least 116 people in northwestern Puerto Rico. A run up of about 20 feet has been documented by mapping, and sedimentary evidence for at least two earlier tsunamis in the area has been cited.

Hazard Frequency and Magnitude

In crude terms, based on a record of approximately 100 recorded tsunamis in the Caribbean over the last 500 years, on average, one tsunami should be expected somewhere in the basin every 5 years. Conversely, Tom Parsons and Eric Geist, in a regional tsunami probability study conducted in 2009 estimate that the 30-year probability of a tsunami with runs up greater than or equal to 0.5 m at Charlotte Amalie is 18%. This combines the probability estimate from the historic catalog with numerical modeling results. The numerical model is based on a coarse grid and not geographically specific, but provides a good indicator of hazard frequency and magnitude.

Data Sources, Models and Methodologies

Tsunami

- Based on oral communication with Tsunami hazard expert, Professor Roy Watlington, UVI
- USGS U.S. Geological Survey, "Earthquakes and Tsunamis in Puerto Rico and the U.S. Virgin Islands", Fact Sheet FS–141–00, 2001
- University of California Tsunami Research Group (http://www.usc.edu/dept/tsunamis/)
- Parson, T and Geist, E (2009): Pure and Applied Geophysics, Vol. 165, 2089-2116
- Guidelines and Best Practices to Establish Areas of Tsunami Inundation for Non-modeled or Low-hazard Regions" (see http://nthmp.tsunami.gov/modeling_guidelines.html).

[12] Database of Caribbean Tsunami observations with runup ≥0.5 meters. Sources NOAA n-line database and Lander 2003.

- Preparing Your Community for Tsunamis – A Guidebook for Local Advocates, Version 2.1, February 1, 2008, Laura Dwelley Samant, L. Thomas Tobin, Brian Tucker (http://www.preventionweb.net/files/3984_PreparingYourCommunityforTsunamisV21.pdf).

Tsunami Hazard Assessment and Determination

- The tsunami hazard maps used in this study were developed based on estimates of a historical event, the tsunami of 1867. The estimated maximum wave height of the tsunami of 1867 was 7 meters.
- Wave height estimates were intersected with a digital elevation model to develop tsunami inundation maps. These maps are based on a historical tsunami scenario and expert interviews. Inundation maps may have no significant bearing on any actual tsunami event and should not be used during a real tsunami event.
- GIS overlay techniques were utilized to identify structures in the inundation areas. Flood depths were not estimated.
- Database of Caribbean Tsunami observations with run up ≥0.5 meters. Sources NOAA n-line database and Lander 2003.

Inventory Data (Assets)

- General Building Stock: Office of the Lt. Governor, Office of the Tax Assessor, Computer Mass Appraisal System Database and GIS Parcel Maps
- Critical Facilities and Infrastructure: VI Department of Property and Procurement, VITEMA

4.4.9 WILDFIRE

Hazard Description

A wildfire is an undesirable, uncontrolled burning of grasslands, brush or woodlands. According to the National Weather Service, more than 100,000 wildfires occur in the United States each year. About 90% of these wildfires are started by humans (i.e., campfires, debris burning, smoking, etc.); the other 10% are started by lightning. Wildfires, by definition, occur in areas where development is sparse and as a result often begin unnoticed and spread quickly.

The potential for wildfire depends upon surface fuel characteristics, weather conditions, recent climate conditions, topography and fire behavior. Fuels are defined as anything that fire can and will burn, and are the combustible materials that sustain a wildfire. Typically, this is the most prevalent vegetation in a given area. Weather is one of the most significant factors in determining the severity of wildfires. The intensity of fires and the rate with which they spread is directly rated to the wind speed, temperature and relative humidity. Climatic conditions such as long-term drought also play a major role in the number and intensity of wildfires, and topography is important because the slope and shape of the terrain can change the rate of speed at which fire travels.

There are four major types of wildfires, they are:

- Ground fires burn in natural litter, duff, roots or sometimes even highly-organic soils. Once started they are very difficult to control, and some ground fires may even rekindle after being extinguished.
- Surface fires burn in grasses and low shrubs (up to 4' tall) or in the lower branches of trees. They have the potential to spread rapidly, and the ease of their control depends upon the fuel involved.
- Crown fires burn in the tops of trees, and the ease of their control depends greatly upon wind conditions.
- Spotting fires occur when burning embers are thrown ahead of the main fire, and can be produced by crown fires as well as wind and topographic conditions. Once spotting fires begin, the fire will be very difficult to control.

Nature of the Hazard

In the US Virgin Islands, the pattern of development in which structures are mixed in with or next to flammable vegetation, increases the territory's susceptibility to wildfires. The US Virgin Islands is considered to have a mixed wild land/urban interface where structures and other human development meet or intermingle with undeveloped vegetative lands.

On the islands of St. Thomas and St. John the wild land/urban intersection usually occurs in areas where homes developed are in steep vegetated areas. Furthermore, access to these areas is made difficult by the steep and narrow roadways. On St. Croix, residential and commercial structures are intermingled with grasslands and/or scrublands. Many of the wildfires on St. Croix tend to be caused by persons burning garbage or clearing their land for cultivation. These wildfires tend to occur in the dry season and spread for hundreds of areas across sparsely populated lands.

Hazard Location, Extent and Distribution

Because high-resolution data was not readily available to accurately identify the degree of wildfire hazard throughout the US Virgin Islands, a precise analysis to determine the geographic extent for the wildfire hazard could not be performed. Instead an approximate analysis mapping was utilized to identify general areas throughout the islands that could be prone to Wildfire (See Figures 4.24, 4.25 and 4.26).

It is necessary to note that historically fires have been man-caused, and limited primarily to St. Croix, and have spread over hundreds of acres.

FIGURE 4.24 ***Wildfire Hazard Map, St. Thomas***

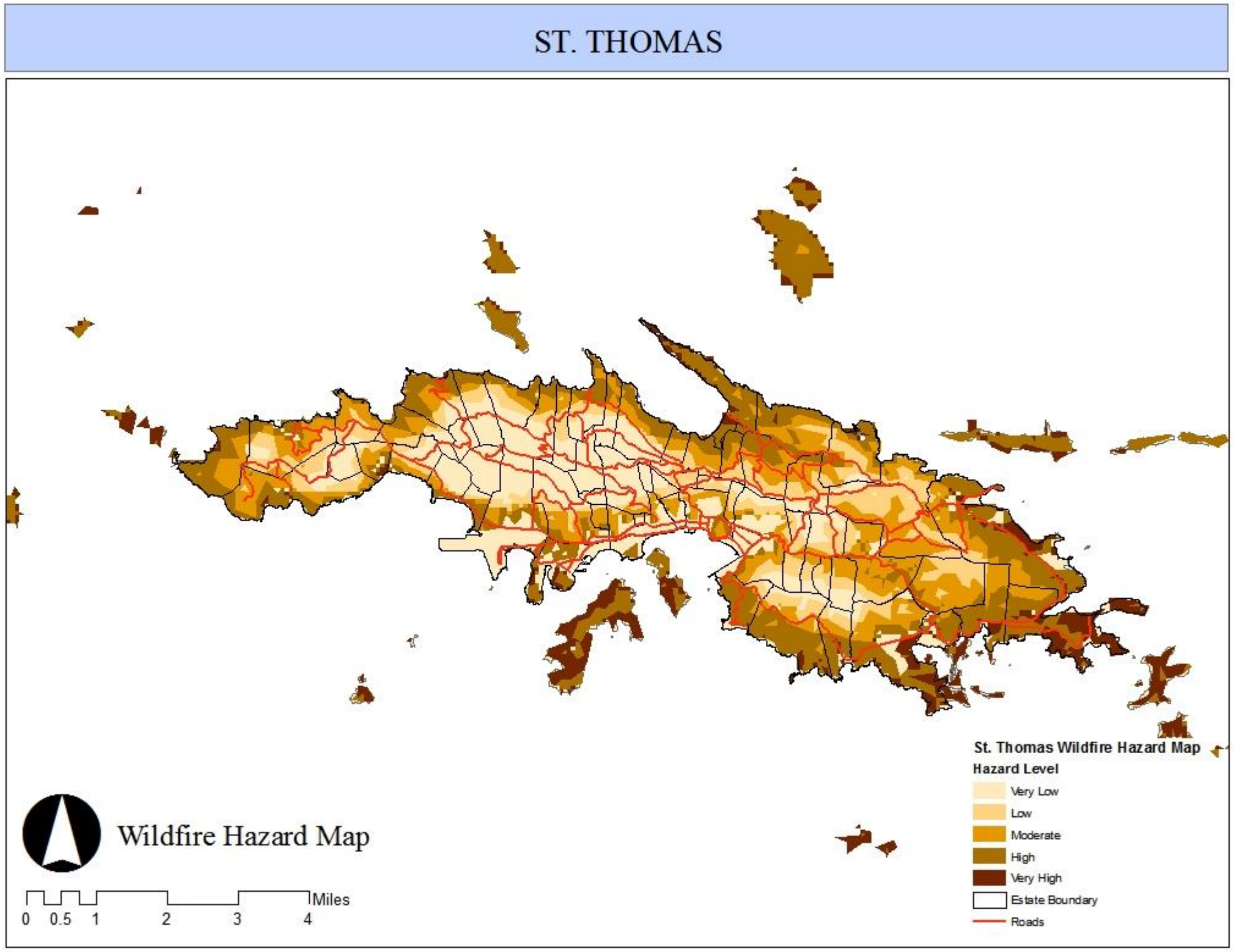


FIGURE 4.25 ***Wildfire Hazard Map, St. Croix***

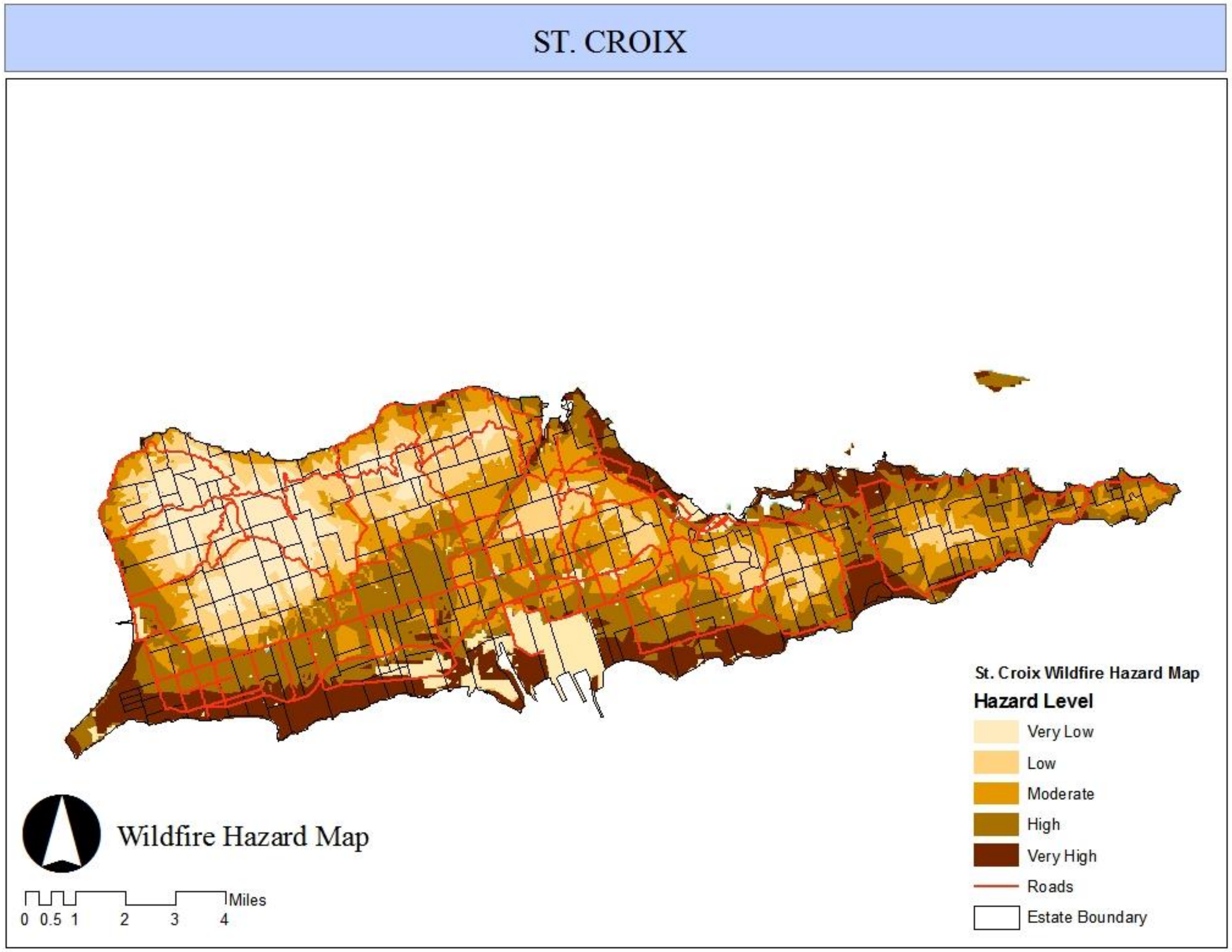
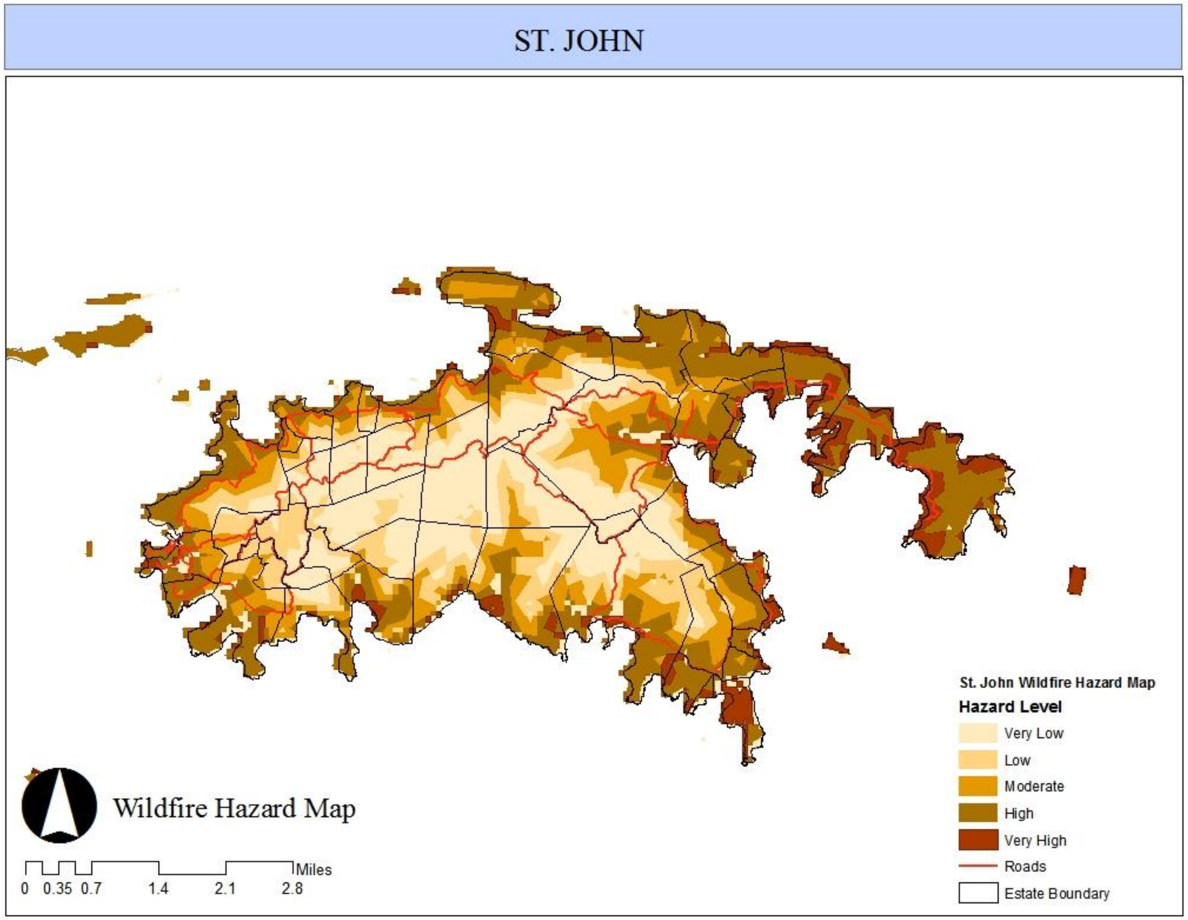


FIGURE 4.26 ***Wildfire Hazard Map, St. John***



Disaster History

The National Climatic Data Center record indicates that there have been only 18 confirmed wild/forest fires in the Territory between 2000 and 2010. All of these events were reported on St. Croix. Below are descriptions taken from the National Climatic Data Center (NOAA's on-line database):

1. April 14, 2000: Approximately 100 acres were burnt by brush fires fueled by dry, windy conditions in St. Croix western end hillsides. The fires began in Calqouhoun and spread to cover a broad area in William's Delight, Queen Louise and Estate Mountain. No homes were destroyed and nobody was injured.

2. March 13, 2000. Brush fires affected about 600 acres of land in Lowry Hill and Tide Village in East End. No damage was reported to homes, structures and nobody was injured. The cause of fire was unknown but arson was suspected.

3. March 18, 2001. Brush fires affected about 100 acres near Mount Welcome and Recovery Hill. No damages were reported on structures, homes or people. The suspected cause of the fire was an abandoned car that someone set afire.

4. March 29, 2001. A brush fire formed at Kingshill Area across the Centerline Road. The fire affected a nearby elementary school with smoke. Four students were taken to the Hospital with respiratory difficulties. All of them were unharmed.

5. April 2, 2001.Brush fires affected about 215 acres of land in Recovery Welcome, Peter's Farm and a section just east of Gallows Bay. No damages were reported on homes, structure or affected any people. The cause of these fires was unknown, but arson was suspected in Gallows Bay.

6. March 13, 2003. Brush fires fueled by strong winds scorched hundreds of acres on St Croix, at Estates Bethlehem, Calguohoun, Cobble, and Lowry Hill. The extremely dry conditions appeared to have spawned multiple fires. Several telephone poles were damaged, and some livestock may have perished. About 60 acres of pasture and brush were lost in Estate Lowry Hill.

7. April 3, 2003. A brush fire was reported near Grassy Point in St Croix. It was burning up in open terrain and hills. A substantial number of acres were burned. Lack of rainfall could have been a contributing factor.

8. March 4, 2005. A brush fire scorched more than 300 acres of vegetation near South Sore cafe in Estate Petronelli. Several utility poles were damaged.

9. March 8, 2005. More than 15 acres of brush was scorched when a fire crept over an open field between Estates Mon Bijou and Calquohoun.

10. March 11, 2011. A brush fire on the east end of the island consumed more than one 100 acres of parched vegetation near Grape Tree Bay. The fire damaged several utility poles.

11. March 13, 2005. Brush fires fueled by brisk winds scorched hundreds of acres on St. Croix. Fires were in estates Bethlehem, Calquohoun and Cobble. The fire damaged several telephone poles and some livestock could have perished.

12. April 13, 2005. Two brush fires developed on the west end of St. Croix, in a field next to Williams's Delight. Morev than 40 acres burned.

13. April 21, 2005. A massive brush fire was reported on the East End. The fire erupted near Tide Village and quickly spread to hillsides surrounding Lowry Hill and Estate Boetzberg. The fire consumed more than 200 acres of hillside and pastureland.

14. March 8, 2007. A large brush fire burnt more than 800 acres near Castle Nugent, Lowry Hill and Estate Sight on Saint Croix's East End.

15. March 14, 2007. A brush fire scorched four acres of grassland near Ha'Penny on the island's south shore.

16. March 19, 2007. A brush fire scorched more than 100 acres in an open field in Estate Concordia east of Frederiksted.

17. March 28, 2007. A brush fire scorched 40 acres at Estate Granard.

18. April 14, 2010. A brush fire broke out on Saint Croix's south shore to the west of Howard Wall Boy Scouts facility. More than 50 acres of pasture and dry vegetation were consumed.

Climate Variability, Hazard Frequency and Magnitude

The historic average occurrence of wildfires in the US Virgin Islands serves as the best value for predicting future expected recurrence. Based on the limited data, US Virgin Islands can expect at least one (1) wildfire event per year. Such predictions are limited by the number of years for which data was available and the recorded damages per event. Therefore, a thorough understanding of magnitude of wildfire events is very limited.

It is important to note that IPPC and PRECIS climate change models predict that temperatures will increase. Taylor et al. (2007) on the basis of the first round of PRECIS simulations driven by the HadAM3P GCM, have shown that the Caribbean is 1°- 5°C warmer in the annual mean by the

2080s (a 30-yr period from 2071 to 2100), and one also characterized by a greater warming in the northwest (Jamaica, Cuba, Hispaniola, and Belize) in comparison to the eastern Caribbean islands, which includes the Virgin Islands. They also predict a greater warming in the summer months than in the drier early months of the year (Taylor, M. A., and Coauthors, 2007).

This combined with the expected incidence of drought provides a clear indication that the occurrence of wildfire events is likely to increase in the future due to climate change.

4.5 INVENTORY OF ASSETS

For the Plan Update, VITEMA utilized a methodology that was consistent with FEMA Publication 386-2, "State and Local Mitigation Planning How-To Guide, Understanding Your Risks—Identifying Hazards and Estimating Losses" (FEMA 2001). This methodology is the same that was utilized for the development of the 2011 Plan. It includes:

- Estimate or count the total number of buildings, value of buildings, and population in your community.
- Determine the proportion of buildings, the value of buildings, and the population in your community or state that are located in hazard areas, and
- Calculate the proportion of assets located in hazard areas.

4.5.1 INVENTORY DATA COLLECTION

Specific assets evaluated for this Plan Update include population, buildings, and critical facilities, including infrastructure. General inventory information was collected from the Office of the Lieutenant Governor's Tax Assessors Office and was used to classify the general building stock. Site specific data was also gathered from VITEMA and the Department of Property and Procurement and used to classify critical facilities and infrastructure. The data utilized in this Plan was aggregated from the fiscal cadastral (tax values) derived from the Lieutenant Governor's Tax Assessors Office. Plans and contain estimates of the price and quantities of structures used for residential and commercial purposes in the U.S. Virgin Islands. The aggregation of data and all estimates of structure costs used actual prices for commercial and residential structures, which were derived from the Office of the Lieutenant Governor's Tax Assessors Office. Update of critical facility information was derived from annual data sets were derived from publicly available data from the Bureau of Economic Analysis (BEA).

Detailed spatial and non-spatial local data were gathered, compiled, and analyzed in a Geographic Information System (GIS). These data are discussed below under the following categories:

- General Building Stock
- Critical Facilities and Infrastructure

General Building Stock

Local tax assessor information was used to develop a detailed inventory of the built environment in the US Virgin Islands. Specifically, the Virgin Islands Tax Assessors Office (Division of the office of the Lt. Governor), provided their parcel maps and property tax valuation database. The database has been updated and was reevaluated. The OLG data was found to be consistent with tax lot information and could be used to identify use of parcel and/or building.

Since the 2011 Plan Update, the Virgin Islands Tax Assessors Office (Division of the office of the Lt. Governor), have made revisions to the property valuations throughout the entire Territory of the Virgin Islands. This revised database was not made available to VITEMA, and as a result, the same database that was utilized during the 2011 Update was utilized to categorize the built environment.

The OLG database; however, had certain limitations related to structure classification and only classified building by general usage. Field surveys were eliminated from the budget and not conducted during this Plan Update. The field investigations that were conducted during the 2005 and 2008 Plan Updates were deemed to be satisfactory to determine the distribution of different building types and to gather structural information for each occupancy class.

In this Update, and in order to conduct basic analyses and gather information that would be useful to determine general loss estimates, structural categories remained the same as in the 2011 Plan Update. The ten (10) model building types remain consistent with field investigations conducted during this Plan Update, these include:

- Low Rise Wood Frame Dwelling,
- Mid-rise Wood Frame Dwelling,
- Low Rise Reinforced Concrete Dwelling,
- Mid Rise Reinforced Concrete Dwelling,
- Low Rise Steel Building,
- Mid Rise Steel Building,
- Low Rise Un-reinforced Masonry Building,
- Mid Rise Un-reinforced Masonry Building,
- Low Rise Reinforced Masonry Building, and
- Mid Rise Reinforced Masonry Building

The distribution of particular building types for each estate boundary for each island was then updated. This facilitated an understanding of the distribution of model building types for a specific occupancy class, at the estate level, for each island. It is necessary to note, however, that based on a rapid inspection of buildings that steel frame buildings a becoming more prevalent for larger institutional buildings.

This analysis provided a basis to estimate the total number of buildings and to aggregate replacement and content values for model building types.

Territorial Facilities and Infrastructure

There were not any changes made to the critical facility listing from the last plan. The listing of critical facilities provided by VITEMA was crossed checked with the listing of facilities included in the 2011 plan. Facilities such as schools, police and fire stations, and hospitals, are known as "critical facilities." Infrastructure is separated into two distinct classes that have substantially different damage and loss characteristics: (1) transportation systems (key roads, ports, airports) and (2) utility infrastructure (electric power stations, potable water treatment plants, wastewater treatment plants, water pumps). The following three-part definition of critical facilities and infrastructure shall apply:

Critical Facilities
Critical facilities are those facilities that provide services to the community and should be functional after a hazard event. They include:

- Government buildings necessary for continuity of operations,
- Hospitals,
- Police stations,
- Fire stations,
- Schools, and
- Homes for the ageing.

Transportation Infrastructure
Transportation Infrastructures are facilities that enable the movement of goods, particularly emergency relief supplies. They include:

- Marine Facilities, and
- Airports.

Utilities and Infrastructure
Utilities and Infrastructure are facilities that, if damaged, could have far-reaching consequences for the environment. They include:

- Electrical Power Generating Plants,
- Water Treatment Plants,
- Wastewater Treatment Plants,
- Potable Water Pumps, and
- Water Tanks.

This list of facilities was provided by VITEMA for this Plan Update. No new data was provided by Department of Property and Procurement for this plan Update, despite several requests being made by the contractor and VITEMA. Therefore, it was determined that a detailed site inspection was not required during this plan update. Instead, information gathered from VITEMA was used to update inventory information.

The 2014 Plan has categorized facilities and infrastructure by their structural characteristics relevant to vulnerability to the prominent hazards identified in the study. In this Plan, like the 2011 Plan, replacement and content values for facilities were determined using the FEMA guideline of content value as a percentage of building replacement value. In the 2014 Plan Update, facility values were updated utilizing a compounded inflation factor for the three year period.

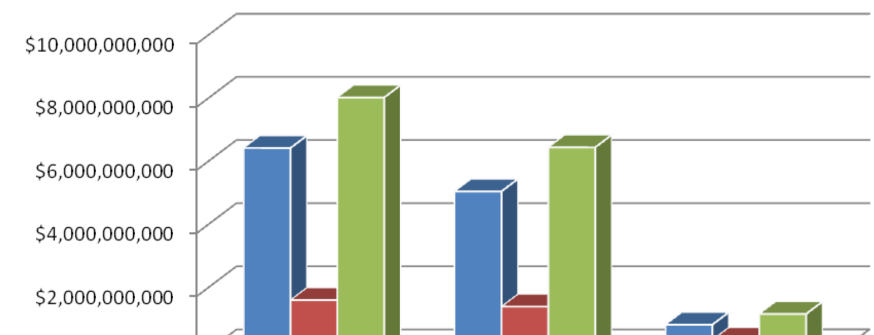
4.5.2 EXPOSURE VALUES

Exposure, as applied in this section of the Plan Update, means, the total amount of property value that are vulnerable to severe loss in the occurrence of a natural hazard event. Exposure is used to quantify the potential financial loss in the event of a natural hazard. Values shown include average building values, structural values (replacement costs), “content value,” and total value.

General Building Stock

Figure 4.25 shows the average estimated value of individual buildings by occupancy class. Exposure values are based on data gathered at the Office of Lieutenant Governor’s office and field investigations. The total inventory value for residential and commercial buildings is $16 billion, which represents an increase of approximately a $2 billion dollars since 2011.

FIGURE 4.25 ***Building Stock Values by Occupancy Class for US Virgin Islands***



	St. Thomas	St. Croix	St. John
Residential	$6,417,782,618	$5,042,503,925	$821,303,378
Commercial	$1,601,294,031	$1,394,636,244	$339,574,266
Total	$8,019,076,649	6,437,140,168	$1,160,877,643

Table 4.9 presents the estimated number of buildings and their dollar value by occupancy class, for each island in the Territory.

TABLE 4.10 ***Inventory of General Building Stock***[13]

Building Occupancy Class	Estimated Number of Buildings 2014	Estimated Aggregate Replacement Cost	Estimated Aggregate Content Value	Total Value
St. Thomas				
Residential	23,365	$ 4,281,518,328.05	$ 2,136,264,289.84	$ 6,417,782,617.89
Commercial	998	$ 800,647,015.35	$ 800,647,015.35	$ 1,601,294,030.70
Total	24,362	$ 5,082,165,343.40	$ 2,936,911,305.19	$ 8,019,076,648.59
St. Croix				
Residential	22,569	$ 4,345,185,802.97	$ 697,318,121.83	$ 5,042,503,924.80
Commercial	841	$ 697,318,121.83	$ 697,318,121.83	$ 1,394,636,243.67
Total	23,410	$ 5,042,503,924.80	$ 1,394,636,243.67	$ 6,437,140,168.47
St. John	0			
Residential	2,230	$ 549,521,425.04	$ 271,781,952.46	$ 821,303,377.50
Commercial	82	$ 271,781,952.46	$ 67,792,313.19	$ 339,574,265.65
Total	2,328	$ 821,303,377.50	$ 339,574,265.65	$ 1,160,877,643.15

For this Plan Update (2014), an in-depth analysis of building stock was not undertaken, but it is a fair assessment that the US Virgin Islands has been affected by the same housing downturn that has affected the US mainland. Values as reflected by inflation multipliers have remained stable in the Territory with St. John receiving the most new construction activity of all three islands. St. Croix, however, has suffered due to the closure of the HOVENSA refinery and has experienced only a modest increase in value of residential and commercial structures as opposed to the 15% increase experienced on St. Thomas and St. John.

Territorial Facilities and Infrastructure

Table 4.11 shows the estimated value of critical facilities and infrastructure in primary categories. Precise valuation information was not readily available from VITEMA or Department of Property and Procurement at the time of the Plan Update; therefore, the values presented in the section are a close approximation of the actual value of these important structures. The valuation of these facilities for this Update was based on the estimated area of the structures and an inflation factor of

[13] Single family dwellings are a subset of the total residential occupancy class. Total values include the sum of residential and commercial occupancy classes.

1.21 for the three year period. This inflation factor was developed through data supplied by the U.S. Department of Commerce, Bureau of Economic Analysis.

TABLE 4.11 ***Estimated Value of Critical Facilities and Infrastructure***

Facility	St. Thomas		St. Croix		St. John	
	# of Facilities in Class	Total Exposure	# of Facilities in Class	Total Exposure	# of Facilities in Class	Total Exposure
Critical Facilities						
Police Stations	5	12,727,552	6	63,719,946	2	4,321,296
Fire Stations	5	7,792,547	5	9,269,808	2	4,845,666
Emergency Response	1	6,472,875		-	1	5,142,339
Hospital/ Medical Clinic	5	95,838,253	3	135,990,389	2	17,590,586
Government Buildings	11	118,417,923	12	121,046,648	3	13,159,486
Shelters	8	123,556,219	11	173,286,506	5	52,473,202
Transportation Infrastructure						
Marine Ports	4	26,038,712	5	9,922,078	1	2,884,325
Airport	1	22,475,260	1	57,686,500	N/A	
Utilities						
Electrical Power Generating Plants	1	51,172,046	1	51,917,850	1	15,575,355
Water Treatment Plants Wastewater Treatment Plants Potable Water Pumps Water Tanks	5	61,792,356	36	110,067,300	4	33,518,154

4.6 VULNERABILITY ASSESSMENT

This section of the Plan Update facilitates an understanding of the proportion of buildings, the value of buildings, and the population located in hazard areas. VITEMA utilized information from the Hazard Identification and Profile information (i.e. wind speed, flood depth, etc.) to assess the vulnerability parameters (specific damage and loss characteristics) of each asset identified.

Vulnerable subgroups of the population for each island were determined using the Census 2010 data. For this Plan Update, population projections for 2014 were prepared accounting for annual growth rate of roughly -.56% (CIA Fact Book). This is lower than growth rate that was utilized in the 2011 Plan Update and is considerably lower than the estimated growth rate for the period 2000-2010. The annual growth rate was applied for four years 2010 to 2014, to estimate population for 2014.

Once the population was projected, the vulnerability analysis looked first at social impacts. The social analysis identified the number of people less than 18 years of age and the number of people over 65 years of age. These two demographic subgroups help define the territory's social vulnerability as they are the most likely to need assistance during and/or after a hazard event. A series of GIS hazard overlay queries were performed to indicate where the people reside within the territory relative to hazards.

Following, the vulnerability assessment was used to estimate potential losses to each hazard. The estimation of how many buildings that are susceptible to hazard related damage are based on either the location of buildings to a particular hazard (i.e. flood zone, earthquake ground shaking level) or based on hazard intensity expressed across each of the Territory's major islands (i.e. wind speed). The pursuant tables identify the number of buildings and value that are exposed to a certain level of hazard intensity. The extent and severity of damage to structural and nonstructural components of a building is described by one of five damage states:

- Very Low, (no, or negligible damage)
- Low, (easily repairable damage mainly to part of nonstructural components and/or contents)
- Moderate, (considerable, yet repairable damage to mainly non-structural components)
- High (considerable damage to both structural and non-structural components), and
- Very High (that the extent of damage is too much to be repaired; the facility has to be demolished and replaced).

The qualitative vulnerability ratings relate to a percentage of damage for each model building type across each island. The damage estimation methods for critical facilities and infrastructure are identical to those utilized to estimate damage with general building stock, except that classification or grouping of facilities was not needed and performed on a structure by structure basis.

4.6.1 DROUGHT

This section discusses the population and the proportion and value of buildings located in areas affected by a drought. It also provides an estimate of proportion of assets located in areas that are susceptible to drought.

Social Impacts

Table 4.12 shows an estimate of the affected population and area (in square kilometers) as indicators of the social vulnerability of each island. Two special needs population segments are broken out by hazard areas: the number of people less than 18 years of age and the number of people over 65 years of age.

TABLE 4.12*Social Impacts (Drought)*

Island Jurisdiction	Total Population	Less than 18 Years of Age in Hazard Area	% Less than 18 Years of Age in Hazard Area	Over 65 Years of Age in Hazard Area	% Over 65 Years of Age in Hazard Area
St. Thomas	54,229	8,876	16%	2,187	4%
St. Croix	56,404	8,271	15%	2,037	4%
St. John	4,447	925	21%	228	5%

Physical and Economic Impacts

- In this Plan Update, economic vulnerability relates to the extent of dollar exposure of its buildings that are susceptible to a hazard. The findings of the vulnerability assessment for this Plan Update indicate that there are 11,215 residential structures exposed to this hazard on St. Thomas and 787 commercial structures. On St. Croix, there are 9,458 residential structures and 192 commercial structures exposed to this hazard, while on St. John the total number of residential properties exposed is 1371and 11 commercial structures.

- On St. Thomas, approximately 48% percent of the residential building stock and 36% of the commercial building stock is considered to be vulnerable to drought. Of this percentage, approximately 26% of the residential building stock is of high vulnerability and the remaining 22% is of very high vulnerability to a drought event. Commercial structures are not considered to be vulnerable to drought events with 35% of the commercial stock being exposed to the hazard, none of which are classified as very high.

- On St. Croix, approximately 43% percent of the residential building stock and 23% of the commercial building stock is considered to be vulnerable to drought. Of this percentage, approximately 34% of the residential building stock is of medium vulnerability, 15% of the residential building stock is of high vulnerability, and the remaining 28% is of very high vulnerability to drought. None of the commercial building inventory is of medium vulnerability, none has high or very high vulnerability rating to a drought event.

- On St. John, approximately 61% percent of the residential building stock and 14% of the commercial building stock is considered to be vulnerable to a drought hazard. Of this percentage, approximately 26% of the residential building stock is of medium vulnerability, 28% of the residential building stock is of high vulnerability, and the remaining 33% is of very high vulnerability to a drought event. None of the commercial building inventory is of medium vulnerability, none has high or very high vulnerability rating to a drought event.

The tables below show potential dollar exposure to drought hazard on St. Thomas, St. Croix and St. John.

TABLE 4.13 ***Estimated Drought Exposure and Vulnerability (St. Thomas)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	48%	13%	23%	16%	26%	22%
No. of Residential	11,215	1,404	5,262	3,836	6,148	5,193
Value of Residential	$3,085,163,402	$386,351,477	$694,754,849	$506,474,402	$811,865,287	$685,717,387
% of Commercial	36%	36%	64%	0	0	0
No. of Commercial	787	284	503	0	0	0
Value of Commercial	$655,447,244	$236,689,283	$418,757,961	$0.00	$0.00	$0.00

TABLE 4.14 ***Estimated Drought Exposure and Vulnerability (St. Croix)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	43%	9%	14%	34%	15%	28%
No. of Residential	9458	822	117	39	6	2
Value of Residential	$2,492,165,251	216,673,928	30,756,222	10,393,800	1,583,133	444,630
% of Commercial	23%	41%	61%	0	0	0
No. of Commercial	192	79	48	0	0	0
Value of Commercial	$331,528,001	135,625,091	82,554,403	0	0	0

TABLE 4.15 ***Estimated Drought Exposure and Vulnerability (St. John)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	61%	2%	12%	26%	28%	33%
No. of Residential	1371	24	164	352	385	446
Value of Residential	$500,995,060	8,631,645	59,792,124	128,575,545	140,893,622	163,102,125
% of Commercial	14%	14%	86%	0%	0%	0%
No. of Commercial	11	2	10	0	0	0
Value of Commercial	$47,540,397	6,791,485	40,748,912	0	0	0

Critical Facilities

The tables below highlight the results of the vulnerability assessment of each state-owned or operated facility to the earthquake hazard. Results define the potential exposure to Territorial Facilities and Infrastructure for the island of St. Thomas, St. Croix and St. John.

TABLE 4.16 ***Estimated Drought Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Thomas)***

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	5	2			2	1	12,727,552
Fire Stations	5	3	2				7,792,547
Emergency Response	1					1	6,472,875
Hospital, Clinics, and special needs	5	4		1			95,838,253
Government Buildings	11	9		9	9		118,417,923
Shelters	5	2	1		1	1	123,556,219
Transportation Infrastructure							
Marine Ports	4	4					26,038,712
Airport	1	1					22,475,260
Utilities							
Electrical Power Generating Plants	1	1					51,172,046
Sewage Treatment Plant	1			1			61,792,356
Water Treatment Plant	1		1				
WAPA Tanks	1			1			
Pumping Station	1	1					

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

TABLE 4.17 *Estimated Drought Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Croix)*

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	6	3	2		1		63,719,946
Fire Stations	5	3		2			9,269,808
Emergency Response	N/A						-
Hospital/ Medical Clinic	3	3					135,990,389
Government Buildings	12	6			2	4	121,046,648
Shelters/Special Needs	11	3			5	3	173,286,506
Transportation Infrastructure							
Marine Ports	5	5					9,922,078
Airport	1	1					57,686,500
Utilities							
Electrical Power Generating Plants	1	1					51,917,850
Sewage Pumps	14	9				5	110,067,300
Wastewater Treatment Plant	1	1					
Water Treatment Plant	1	1					
Water Pumps	8	1	4	3			

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

TABLE 4.18 ***Estimated Drought Exposure and Vulnerability, Critical Facilities and Infrastructure (St. John)***

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	2	1		1		2	4,321,296
Fire Stations	2	1					4,845,666
Emergency Response	1						5,142,339
Hospital/ Medical Clinic	2			1		1	17,590,586
Government Buildings	3	3					13,159,486
Shelters/Special Needs	5	1		2		2	52,473,202
Transportation Infrastructure							-
Marine Ports	1	1					2,884,325
Airport	N/A						
Utilities							-
Electrical Power Generating Plants	1	1					15,575,355
WAPA Desalinization Plant	1	1					
WAPA Water Tank	1	1					
Sewage Treatment Plant	1	1					
Potable Water Tank	1	1					33,518,154

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

4.6.2 EARTHQUAKE

This section discusses the population and the proportion and value of buildings located in areas affected by an earthquake hazard. It also provides an estimate of proportion of assets located in earthquake hazard areas.

Social Impacts

Table 4.30 shows an estimate of the affected population and area (in square kilometers) as indicators of the social vulnerability of each island. Two special needs population segments are broken out by hazard areas: the number of people less than 18 years of age and the number of people over 65 years of age.

TABLE 4.19*Social Impacts (Earthquake)*

Island Jurisdiction	Total Population	Less than 18 Years of Age in Hazard Area	% Less than 18 Years of Age in Hazard Area	Over 65 Years of Age in Hazard Area	% Over 65 Years of Age in Hazard Area
St. Thomas	54,229	5,965	11%	1,627	3%
St. Croix	56,404	8,461	15%	1,692	3%
St. John	4,447	623	14%	178	4%

Physical and Economic Impacts

In this Plan Update, economic vulnerability relates to the extent of dollar exposure of its buildings. The findings of the vulnerability assessment for this Plan Update indicate that there was an increase of 558 residential properties exposed to this hazard on St. Thomas. On St. Croix, there was an increase of 405 residential properties exposed to this hazard, while on St. John the total number of residential properties exposed increased by 41. On St. Thomas there were 55 additional commercial properties exposed to this hazard. In St. Croix there was an increase of 18 commercial properties exposed to this hazard. On St. John there were 2 less commercial properties exposed to this hazard.

- On St. Thomas approximately 91% percent of the residential building stock and 96% of the commercial building stock is considered to be vulnerable to an earthquake event. Of this percentage, approximately 42% of the residential building stock is of high vulnerability and the remaining 58% is of very high vulnerability to an earthquake event. About 20% of the commercial building inventory is of high vulnerability to an earthquake and the remaining 80% of the inventory has a very high vulnerability to a seismic event.

- On St. Croix approximately 70% percent of the residential building stock and 84% of the commercial building stock is considered to be vulnerable to an earthquake event. Of this percentage, approximately 75% of the residential building stock is of medium vulnerability, 5% of the residential building stock is of high vulnerability, and the remaining 20% is of very high vulnerability to an earthquake event. About 84% of the commercial building inventory is of medium vulnerability, none has high vulnerability, and the remaining 27% of the inventory has a very high vulnerability to a seismic event.

- On St. John approximately 71% percent of the residential building stock and 85% of the commercial building stock is considered to be vulnerable to an earthquake event. Of this percentage, approximately 71% of the residential building stock is of medium vulnerability, 11% of the residential building stock is of high vulnerability, and the remaining 19% is of very high vulnerability to an earthquake event. About 32% of the commercial building inventory is of medium vulnerability to an earthquake, 20% of the stock is of high vulnerability, and the remaining 48% of the inventory has a very high vulnerability to a seismic event. St. John has construction on steep sloping ground, but most structures are more recent and better built due to economic reasons.

The tables below show potential dollar exposure to earthquake hazard on St. Thomas, St. Croix and St. John.

TABLE 4.20 ***Estimated Earthquake Exposure and Vulnerability (St. Thomas)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	91%	0.00	0.00	0.00	42%	58%
No. of Residential	21,262	0	0	0	9,807	13,558
Value of Residential	$5,848,955,616	$0	$0	$0	$2,697,864,850	$3,729,558,904
% of Commercial	96%	0.00	0.00	0.00	20%	80%
No. of Commercial	2,098	0	0	0	435	1,750
Value of Commercial	$1,747,859,317	$0	$0	$0	$362,197,527	$1,458,489,262

TABLE 4.21 ***Estimated Earthquake Exposure and Vulnerability (St. Croix)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	70%	0%	0%	75%	5%	20%
No. of Residential	15,398	0	0	16,497	1,100	4,399
Value of Residential	4,057,013,200	0	0	3,042,759,900	202,850,660	811,402,640
% of Commercial	84%	0%	0%	73%	0%	27%
No. of Commercial	701	0	0	512	0	189
Value of Commercial	1,210,797,916	0	0	883,882,479	0	326,915,437

TABLE 4.22 ***Estimated Earthquake Exposure and Vulnerability (St. John)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	71%	0	0	71%	11%	19%
No. of Residential	1,595	0	0	1,133	175	303
Value of Residential	583,125,398	0	0	414,019,033	64,143,794	110,793,826
% of Commercial	85%	0	0	32%	20%	48%
No. of Commercial	69	0	0	22	14	33
Value of Commercial	288,638,126	0	0	92,364,200	57,727,625	138,546,300

Critical Facilities

The tables below highlight the results of the vulnerability assessment of each state-owned or operated facility to the earthquake hazard. Results define the potential exposure to Territorial Facilities and Infrastructure for the island of St. Thomas, St. Croix and St. John.

TABLE 4.23 ***Estimated Earthquake Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Thomas)***

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	5	1			1	3	12,727,552
Fire Stations	5	1		1	1	2	7,792,547
Emergency Response				1			6,472,875
Hospital, Clinics, and special needs	5				4	1	95,838,253
Government Buildings	11			3		8	118,417,923
Shelters	5	1		1		3	123,556,219
Transportation Infrastructure							
Marine Ports	4	1		1		2	26,038,712
Airport	1	1					22,475,260
Utilities							
Electrical Power Plant						1	51,172,046
Sewage Treatment Plant	1				1		61,792,356
Water Treatment Plant	1				1		
WAPA Tanks	1					1	
Pumping Station	1				1		

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

TABLE 4.24 ***Estimated Earthquake Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Croix)***

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	6	1		3	1	1	63,719,946
Fire Stations	5	1			1	3	9,269,808
Emergency Response	1			1			-
Hospital/ Medical Clinic	3			2		1	135,990,389
Government Buildings	12			6	2	4	121,046,648
Shelters/Special Needs	11		1	3	1	6	173,286,506
Transportation Infrastructure							
Marine Ports	5	5					9,922,078
Airport	1			1			57,686,500
Utilities							
Electrical Power Plant	1				1		51,917,850
Sewage Pumps	14	3	3	6	2		110,067,300
Wastewater Treatment Plant	1				1		
Water Treatment Plant	1	1					
Water Pumps	8			4	2	2	

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

TABLE 4.25 ***Estimated Earthquake Exposure and Vulnerability, Critical Facilities and Infrastructure (St. John)***

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	2		1		1		4,321,296
Fire Stations	2			1		1	4,845,666
Emergency Response	1			1			5,142,339
Hospital/ Medical Clinic	2	1				1	17,590,586
Government Buildings	3		1			2	13,159,486
Shelters/Special Needs	5			1	1	3	52,473,202
Transportation Infrastructure							-
Marine Ports	1	1					2,884,325
Airport	N/A						--
Utilities							-
Electrical Power Plant	1				1		15,575,355
WAPA Desalinization Plant	1			1			
WAPA Water Tank	1				1		
Sewage Treatment Plant	1				1		
Potable Water Tank	1				1		
							33,518,154

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

4.6.3 Riverine Flooding

This section discusses the population and the proportion and value of buildings located in areas affected by a riverine flooding hazard. It also provides an estimate of proportion of assets located in riverine flooding hazard areas.

Social Impacts

Table 4.25 shows an estimate of the affected population and area (in square kilometers) as indicators of the social vulnerability of each island. Two special needs population segments are broken out by hazard areas: the number of people less than 18 years of age and the number of people over 65 years of age.

TABLE 4.26 ***Social Impacts (Riverine Flooding)***

Island Jurisdiction	Total Population	Less than 18 Years of Age in Hazard Area	% Less than 18 Years of Age in Hazard Area	Over 65 Years of Age in Hazard Area	% Over 65 Years of Age in Hazard Area
St. Thomas	54,229	3,796	7%	1,085	2%
St. Croix	56,404	4,512	8%	1,128	2%
St. John	4,447	267	6%	44	1%

Physical and Economic Impacts

In this Plan Update, economic vulnerability relates to the extent of dollar exposure of its buildings. The findings of the vulnerability assessment for this Plan Update indicate that there was an increase of 141 residential properties exposed to this hazard on St. Thomas. On St. Croix there was an increase of 70 residential properties exposed to this hazard, while on St. John the total number of residential properties exposed to this hazard increased by 14. On St. Thomas there were 21 more commercial properties exposed to this hazard. On St. Croix there were 2 more commercial properties exposed to this hazard. On St. John there were not any additional commercial properties exposed to this hazard.

- On St. Thomas approximately 23% percent of the residential building stock and 36% of the commercial building stock is considered to be vulnerable to river flooding. Of this percentage, approximately 47% of the residential building stock is of medium vulnerability and the remaining 53% is of high vulnerability to river flooding. About 36% of the commercial building inventory has a low vulnerability to river flooding, and the remaining 79% of the inventory has a high vulnerability to such flooding.

- On St. Croix approximately 12% percent of the residential building stock and 10% of the commercial building stock is considered to be vulnerable to river flooding. Of this percentage, approximately 68% of the residential building stock is of medium vulnerability and the remaining 32% is of high vulnerability to river flooding. About 51% of the commercial building inventory has a low vulnerability to river flooding, and the remaining 49% of the inventory has a high vulnerability to such flooding.

- On St. John approximately 12% percent of the residential building stock and 10% of the commercial building stock is considered to be vulnerable to river flooding. Of this percentage, approximately 81% of the residential building stock is of medium vulnerability and the remaining 19% is of high vulnerability to river flooding. About 51% of the commercial building inventory has a moderate vulnerability to river flooding, and the remaining 49% of the inventory has a high vulnerability to such flooding.

TABLE 4.27 ***Estimated Riverine Flooding Exposure and Vulnerability (St. Thomas)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	23%	0.00	0.00	0.47	0.53	0.00
No. of Residential	5,374	0	0	2,519	2,855	0
Value of Residential	$1,478,307,463	$0.00	$0.00	$692,844,520	$785,462,943	$0.00
% of Commercial	36%	0.00	0.00	20	79	0.00
No. of Commercial	787	0	0	156	630	0
Value of Commercial	$655,447,244	$0	$0	$130,391,110	$525,056,134	0

TABLE 4.28 *Estimated Riverine Flooding Exposure and Vulnerability (St. Croix)*

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	12%	0%	0%	68%	32%	0%
No. of Residential	2,640	0	0	1,795	845	0
Value of Residential	695,487,977	0	0	472,931,824	222,556,153	0
% of Commercial	10%	0%	0%	51%	49%	0%
No. of Commercial	83	0	0	43	41	0
Value of Commercial	144,142,609	0	0	73,512,731	70,629,878	0

TABLE 4.29 *Estimated Riverine Flooding Exposure and Vulnerability (St. John)*

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	24%	0%	0%	81%	19%	0%
No. of Residential	539	0	0	437	102	0
Value of Residential	197,112,811	0	0	159,661,377	37,451,434	0
% of Commercial	15%	0%	0%	44%	48%	0%
No. of Commercial	12	0	0	5	6	0
Value of Commercial	50,936,140	0	0	22,411,902	24,449,347	0

It may be overly simplistic to determine flood vulnerability as a yes or no per the location of the structure in, or outside of, the floodplain. Flood vulnerability for this Plan Update was determined using the 100-year flood zone as an indicator of the overall hazard. The digital version of these maps was derived from updated DFIRMS. However, the updated DFIRMS did not have Base Flood Elevations (BFE) for all mapped riverine areas.

Therefore, BFEs were utilized where present and a terrain model was utilized to infer flood elevations where the BFE data was absent. The resulting analysis utilized a GIS to generate a Triangular Irregular Network (TIN) of the water surface elevation. Using GIS overlay techniques, the terrain were subtracted from TIN (an intersection of the flood polygon with the terrain model) to determine an estimated depth of flooding.

This method was found to be suitable for estimating zones experiencing different flood depths within the 100-year flood area. The depth intervals were broken out into five categories of different flood depths between 4 to 25 feet to define the flood hazard as very low, low, moderate, high and very high. Therefore, your highest areas of vulnerability would be found in the center of the 100-year floodplain, where the depths are the greatest. In this Plan Update, most of the residential and commercial structures in the Territory were found to be in moderate to high flood hazard intensity. This indicates that most the building stock estimated to be vulnerable to flooding were within the defined 100-year floodplain.

The flood hazard information in this Plan Update was used to integrate a Severe Repetitive Loss Strategy in the Mitigation Strategy. As in the 2011 Plan Update, general GIS maps that graphically show Special Flood Hazard Area (SFHA) were used to identify residential and commercial areas that experience repetitive flooding. Mapping of individual structures was not conducted during this Plan Update.

Critical Facilities

The following tables highlight the results of the vulnerability assessment of each state-owned or operated facility to the riverine flood hazard. Results define the potential exposure to Territorial Facilities and Infrastructure for the islands of St. Thomas, St. Croix and St. John.

The tables below show potential dollar exposure to Riverine flood hazard on St. Thomas, St. Croix and St. John.

TABLE 4.30 ***Estimated Riverine Flooding Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Thomas)***

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	5	2			1	2	12,727,552
Fire Stations	5	2		1		2	7,792,547
Emergency Response	1	1					6,472,875
Hospital, Clinics, and special needs	5	3	1			1	95,838,253
Government Buildings	11	3		1	2	5	118,417,923
Shelters	5	3		1	1		123,556,219
Transportation Infrastructure							
Marine Ports	4	3		1			26,038,712
Airport	1	1					22,475,260
Utilities							
Electrical Power Plant							51,172,046
Sewage Treatment Plant	1				1		61,792,356
Water Treatment Plant	1				1		
WAPA Tanks	1	1					
Pumping Station	1	1					

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

<u>TABLE 4.31</u> *Estimated Riverine Flooding Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Croix)*

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	6	6					63,719,946
Fire Stations	5	5					9,269,808
Emergency Response	1	1					-
Hospital/ Medical Clinic	3	3					135,990,389
Government Buildings	12	9		1	1		121,046,648
Shelters/Special Needs	11	11				1	173,286,506
Transportation Infrastructure							
Marine Ports	5	5					9,922,078
Airport	1	1					57,686,500
Utilities							
Electrical Power Plant	1		1				51,917,850
Sewage Pumps	14	**12**	2				110,067,300
Wastewater Treatment Plant	1	**1**					
Water Treatment Plant	1		1				
Water Pumps	8	**6**	1	1			

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

TABLE 4.32 ***Estimated Riverine Flooding Exposure and Vulnerability, Critical Facilities and Infrastructure (St. John)***

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	2	1			1		4,321,296
Fire Stations	2	2					4,845,666
Emergency Response	1	1					5,142,339
Hospital/ Medical Clinic	2	2					17,590,586
Government Buildings	3	2			1		13,159,486
Shelters/Special Needs	5	3				2	52,473,202
Transportation Infrastructure							-
Marine Ports	1						2,884,325
Airport	N/A						--
Utilities							-
Electrical Power Plant	1	1					15,575,355
WAPA Desalinization Plant	1	1					
WAPA Water Tank	1	1					
Sewage Treatment Plant	1				1		
Potable Water Tank	1	1					33,518,154

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

4.6.4 COASTAL FLOODING

This section discusses the population and the proportion and value of buildings located in areas affected by a coastal flood hazard. It also provides an estimate of proportion of assets located in coastal flood hazard areas.

Social Impacts

Table 4.33 shows an estimate of the affected population and area (in square kilometers) as indicators of the social vulnerability of each island. Two special needs population segments are broken out by hazard areas: the number of people less than 18 years of age and the number of people over 65 years of age.

TABLE 4.33 ***Social Impacts (Coastal Flooding)***

Island Jurisdiction	Total Population	Less than 18 Years of Age in Hazard Area	% Less than 18 Years of Age in Hazard Area	Over 65 Years of Age in Hazard Area	% Over 65 Years of Age in Hazard Area
St. Thomas	54,229	1,085	2%	16	0.03%
St. Croix	56,404	1,128	2%	23	0.04%
St. John	4,447	89	2%	2	0.04%

Physical and Economic Impacts

In this Plan update economic vulnerability relates to the extent of dollar exposure of its buildings. The findings of the vulnerability assessment for this Plan Update indicate that there was an increase of 43 residential properties exposed to this hazard on St. Thomas. On St. Croix there was an increase 29 residential properties, while on St. John the total number of residential properties exposed increased by 6. On St. Thomas the total number of commercial properties increased by 2. On St. Croix there were 1 more commercial property exposed to this hazard and on St. John, there was no change.

- On St. Thomas approximately 7% percent of the residential building stock and 4% of the commercial building stock is considered to be vulnerable to coastal flooding. Of this percentage, approximately 2% of the residential building stock is of medium vulnerability, 45% of the residential building stock is of high vulnerability, and the remaining 53% is of very high vulnerability to coastal flooding. About 1% of the commercial building inventory is of medium vulnerability to coastal flooding, 19% of the stock is of high vulnerability, and the remaining 80% of the inventory has a very high vulnerability to such flooding.

- On St. Croix approximately 5% percent of the residential building stock and 2% of the commercial building stock is considered to be vulnerable to coastal flooding. Of this percentage, approximately 1% of the residential building stock is of medium vulnerability, 76% of the residential building stock is of high vulnerability, and the remaining 24% is of very high vulnerability to coastal flooding. About 4% of the commercial building inventory is of medium vulnerability to coastal flooding, 67% of the stock is of high vulnerability, and the remaining 29% of the inventory has a very high vulnerability to such flooding.

- On St. John approximately 10% percent of the residential and commercial building stock are considered to be vulnerable to coastal flooding. Of this percentage, approximately 1% of the residential building stock is of medium vulnerability, 76% of the residential building stock is of high vulnerability, and the remaining 23% is of very high vulnerability to coastal flooding. About 4% of the commercial building inventory is of medium vulnerability to coastal flooding, 47% of the stock is of high vulnerability, and the remaining 49% of the inventory has a very high vulnerability to such flooding.

The tables below show potential dollar exposure to the coastal flooding hazard on St. Thomas, St. Croix and St. John.

***TABLE 4.34* Estimated Coastal Flooding Exposure and Vulnerability (St. Thomas)**

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	7%	0.00	0.00	0.02	0.45	0.53
No. of Residential	1,636	0	0	29	738	869
Value of Residential	$449,919,663	0	0	7,936,939	202,928,784	239,053,939
% of Commercial	4%	0.00	0.00	0.01	0.19	0.80
No. of Commercial	87	0	0	1	16	70
Value of Commercial	$72,827,472	$0	$0	$929,427	$13,558,474	$58,339,570

TABLE 4.35 ***Estimated Coastal Flooding Exposure and Vulnerability (St. Croix)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	5%	0%	0%	1%	76%	24%
No. of Residential	1,100	0	0	11	836	264
Value of Residential	289,786,657	0	0	2,897,867	220,237,859	69,548,798
% of Commercial	2%	0	0	4%	67%	29%
No. of Commercial	17	0	0	3	54	23
Value of Commercial	28,828,522	0	0	57,657,044	965,755,481	418,013,566

TABLE 4.36 ***Estimated Coastal Flooding Exposure and Vulnerability (St. John)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	10%	0%	0%	1%	76%	23%
No. of Residential	225	0	0	2	171	52
Value of Residential	82,130,338	0	0	821,303	62,419,057	18,889,978
% of Commercial	10%	0	0	4%	47%	49%
No. of Commercial	8	0	0	0	4	4
Value of Commercial	33,957,427	0	0	1,358,297	15,959,990	16,639,139

Critical Facilities

The following tables highlight the results of the vulnerability assessment of each state-owned or operated facility to the coastal flood hazard. Results define the potential exposure to Territorial Facilities and Infrastructure for the island of St. Thomas, St. Croix and St. John.

TABLE 4.37 ***Estimated Coastal Flooding Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Thomas)***

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	5	5					12,727,552
Fire Stations	5	5					7,792,547
Emergency Response	1	1					6,472,875
Hospital, Clinics, and special needs	5	5					95,838,253
Government Buildings	11	11					118,417,923
Shelters	5	5					123,556,219
Transportation Infrastructure							
Marine Ports	4	4					26,038,712
Airport	1	1					22,475,260
Utilities							
Electrical Power Plant	1	1					51,172,046
Sewage Treatment Plant	1	1					61,792,356
Water Treatment Plant	1	1					
WAPA Tanks	1	1					
Pumping Station	1	1					

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

TABLE 4.38 ***Estimated Coastal Flooding Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Croix)***

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	6	6					63,719,946
Fire Stations	5	5					9,269,808
Emergency Response	1	1					-
Hospital/ Medical Clinic	3	3					135,990,389
Government Buildings	12	11				1	121,046,648
Shelters/Special Needs	11	11					173,286,506
Transportation Infrastructure							
Marine Ports	5	5					9,922,078
Airport	1	1					57,686,500
Utilities							
Electrical Power Plant	1	1					51,917,850
Sewage Pumps	14	14					110,067,300
Wastewater Treatment Plant	1	1					
Water Treatment Plant	1	1					
Water Pumps	8	8					

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

TABLE 4.39 ***Estimated Coastal Flooding Exposure and Vulnerability, Critical Facilities and Infrastructure (St. John)***

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	2	2					4,321,296
Fire Stations	2	2					4,845,666
Emergency Response	1	1					5,142,339
Hospital/ Medical Clinic	2	2					17,590,586
Government Buildings	3	2				1	13,159,486
Shelters/Special Needs	5	5					52,473,202
Transportation Infrastructure							-
Marine Ports	1	1					2,884,325
Airport	N/A						--
Utilities							-
Electrical Power Plant	1					1	15,575,355
WAPA Desalinization Plant	1	1					
WAPA Water Tank	1					1	
Sewage Treatment Plant	1					1	
Potable Water Tank	1	1					33,518,154

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

4.6.5 Hurricane Winds

This section discusses the population and the proportion and value of buildings located in areas affected by a Hurricane Winds hazard. It also provides an estimate of proportion of assets located in Hurricane Winds hazard areas.

Although there no areas of the US Virgin Islands that are totally free from hurricane force winds, the vulnerability of each islands building inventory is quite different. The tables above indicate that the vulnerability of each island's building stock differs. Since vulnerability refers to the potential of the built environment to be damaged or destroyed, the number of certain model buildings types that found throughout each island, e.g., single-family wood-frame buildings, may experience particular states of damage to the hurricane wind hazard (ranging from Very Low, Low, Moderate, High, to Very High).

Social Impacts

Table 4.40 shows an estimate of the affected population and area (in square kilometers) as indicators of the social vulnerability of each island. Two special needs population segments are broken out by hazard areas: the number of people less than 18 years of age and the number of people over 65 years of age.

TABLE 4.40 ***Social Impacts (Hurricane Winds)***

Island Jurisdiction	Total Population	Less than 18 Years of Age in Hazard Area	% Less than 18 Years of Age in Hazard Area	Over 65 Years of Age in Hazard Area	% Over 65 Years of Age in Hazard Area
St. Thomas	54,229	11,388	21%	2,711	5%
St. Croix	56,404	14,101	25%	2,820	5%
St. John	4,447	1,067	24%	267	6%

Physical and Economic Impacts

In this Plan update, economic vulnerability relates to the extent of dollar exposure of its buildings. The findings of the vulnerability assessment for this Plan Update indicate that there was an increase of 331 residential properties exposed to this hazard on St. Thomas. On St. Croix, there were 9239 residential properties exposed to the hazard, which represented an increase of 243 properties. On St. John, there were 786 residential properties, which represented an increase of 2 structures that are exposed high winds. On St. Thomas, there were 41 more commercial properties exposed to this hazard. While in St. Croix, there were 31 more commercial properties and no increase in commercial properties on St. John.

- On St. Thomas, approximately 54% percent of the residential building stock and 70% of the commercial building stock is considered to be vulnerable to hurricane winds. Of this percentage, 1% of the residential building stock is of low vulnerability to hurricane force winds, 94% is of medium vulnerability, and the remaining 5% is of high vulnerability to such winds. Nearly 1% of the commercial building inventory has a low vulnerability to hurricane force winds, and the remaining 99% of commercial building inventory has a medium vulnerability to such winds.

- On St. Croix, approximately 42% percent of the residential building stock and 58% of the commercial building stock is considered to be vulnerable to hurricane winds. Of this percentage, 83% of the residential building stock is of low vulnerability to hurricane force winds, 12% is of medium vulnerability, and the remaining 5% is of high vulnerability to such winds. Nearly 69% of the commercial building inventory has a low vulnerability to hurricane force winds, and the remaining 31% of the inventory has a medium vulnerability to such winds.

- On St. John, approximately 35% percent of the residential and commercial building stock are is considered to be vulnerable to hurricane winds. Of this percentage, 86% of the residential building stock is of low vulnerability to hurricane force winds, 9% is of medium vulnerability, and the remaining 5% is of high vulnerability to such winds. Nearly 73% of the commercial building inventory has a low vulnerability to hurricane force winds, and the remaining 27% of the inventory has a medium vulnerability to such winds.

The tables below show potential dollar exposure to the hurricane hazard on St. Thomas, St. Croix and St. John.

TABLE 4.41 ***Estimated Hurricane Exposure and Vulnerability (St. Thomas)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	54%	0%	1%	94%	5%	0%
No. of Residential	12,617	0	126	11860	631	0
Value of Residential	$3,470,808,827	$0	$34,708,088	$3,262,560,297	$173,540,441	$0
% of Commercial	70%	0%	1%	99%	0%	0%
No. of Commercial	1530	0	28	2157	0	0
Value of Commercial	$1,274,480,752	$0	$23,235,666	$1,797,451,122	$0	$0

TABLE 4.42 ***Estimated Hurricane Exposure and Vulnerability (St. Croix)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	42%	0%	83%	12%	5%	0%
No. of Residential	9,239	0	7,668	1,109	462	0
Value of Residential	2,434,207,920	0	2,020,392,573	292,104,950	121,710,396	0
% of Commercial	58%	0%	69%	31%	0%	0%
No. of Commercial	484	0	334	150	0	0
Value of Commercial	1,441,426,090	0	994,584,002	446,842,088	0	0

TABLE 4.43 ***Estimated Hurricane Exposure and Vulnerability (St. John)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	35%	0	0.86	0.09	0.05	0
No. of Residential	786	0	676	71	39	0
Value of Residential	287,456,182	0	247,212,317	25,871,056	14,372,809	0
% of Commercial	35%	0	0.73	0.27	0	0
No. of Commercial	28	0	21	8	0	0
Value of Commercial	118,850,993	0	86,761,225	32,089,768	0	0

Critical Facilities and Infrastructure

The following tables highlight the results of the vulnerability assessment of each state-owned or operated facility to the Hurricane Wind hazard. Results define the potential exposure to Territorial Facilities and Infrastructure for the island of St. Thomas, St. Croix and St. John.

TABLE 4.44 ***Estimated Hurricane Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Thomas)***

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	5			3	1		12,727,552
Fire Stations	5		1	2	2		7,792,547
Emergency Response	1		1				6,472,875
Hospital, Clinics, and special needs	5		1	2	2		95,838,253
Government Buildings	11		2	1	6	2	118,417,923
Shelters	5			1	4		123,556,219
Transportation Infrastructure							
Marine Ports	4	1	1	1	1		26,038,712
Airport	1		1				22,475,260
Utilities							
Electric Power Plant	1		1				51,172,046
Sewage Treatment Plant	1		1				
Water Treatment Plant	1		1				
WAPA Tanks	1		1				61,792,356
Pumping Station	1		1				

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

<u>TABLE 4.45</u> *Estimated Hurricane Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Croix)*

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	6		4	2			63,719,946
Fire Stations	5	1			1	3	9,269,808
Emergency Response	1		1				-
Hospital/ Medical Clinic	3			2		1	135,990,389
Government Buildings	12			6	2	4	121,046,648
Shelters/Special Needs	11		1	3	1	6	173,286,506
Transportation Infrastructure							
Marine Ports	5	4	1				9,922,078
Airport	1			1			57,686,500
Utilities							
Electrical Power Plant	1		1				51,917,850
Sewage Pumps	14	3	2	3	4	2	
Wastewater Treatment Plant	1		1				
Water Treatment Plant	1		1				110,067,300
Water Pumps	8		8				
Water Tanks	12	2	3	3	4		

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

TABLE 4.46 ***Estimated Hurricane Exposure and Vulnerability, Critical Facilities and Infrastructure (St. John)***

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	2		1		1		4,321,296
Fire Stations	2		1		1		4,845,666
Emergency Response	1		1				5,142,339
Hospital/ Medical Clinic	2		1			1	17,590,586
Government Buildings	3		2		1		13,159,486
Shelters/Special Needs	5			2	3		52,473,202
Transportation Infrastructure							-
Marine Ports	1		1				2,884,325
Airport	N/A						
Utilities							-
Electrical Power Plant	1		1				15,575,355
WAPA Desalinization Plant	1		1				
WAPA Water Tank	1		1				
Sewage Treatment Plant	1		1				
Potable Water Tank	1	1					33,518,154

4.6.6 RAIN-INDUCED LANDSLIDES

This section discusses the population and the proportion and value of buildings located in areas affected by a rain-induced landslides. It also provides an estimate of proportion of assets located in areas that are susceptible to rain-induced landslides

Social Impacts

Table 4.48 shows an estimate of the affected population and area (in square kilometers) as indicators of the social vulnerability of each island. Two special needs population segments are broken out by hazard areas: the number of people less than 18 years of age and the number of people over 65 years of age.

TABLE 4.48 ***Social Impacts (Rain-induced Landslide)***

Island Jurisdiction	Total Population	Less than 18 Years of Age in Hazard Area	% Less than 18 Years of Age in Hazard Area	Over 65 Years of Age in Hazard Area	% Over 65 Years of Age in Hazard Area
St. Thomas	54,229	9,246	17%	2,278	4%
St. Croix	56,404	3,462	6%	853	2%
St. John	4,447	1,516	34%	146	3%

Physical and Economic Impacts

In this Plan Update, economic vulnerability relates to the extent of dollar exposure of its buildings that are susceptible to this hazard. The findings of the vulnerability assessment for this Plan Update indicate that there are 11,682 residential structures and 830 commercial structures exposed to this hazard on St. Thomas. On St. Croix there are 3,959 residential structures and 150 commercial structures exposed to this hazard on St. Thomas. On St. John there are 876 residential structures and 30 commercial structures exposed to this hazard.

- On St. Thomas approximately 50% percent of the residential building stock and 38% of the commercial building stock is considered to be vulnerable rain-induced landslides. Of this percentage, approximately 13% of the residential building stock is of high vulnerability and the remaining 27% is of very high vulnerability to rain-induced landslide event. Commercial structures are considered to be less vulnerable to rain–induced landslide with the majority of structures falling into the very low and low susceptibility categories.

- On St. Croix approximately 18% percent of the residential building stock susceptible to landslide hazards. Of this percentage, approximately 17% of the residential building stock is of medium vulnerability, 13% of the residential building stock is of high vulnerability, and the remaining 5% is of very high vulnerability to rain-induced landslide. None of the commercial building inventory falls into the medium, high or very high vulnerability hazard rating for a rain-induced landslide.

- On St. John approximately 39% percent of the residential building stock and 37% of the commercial building stock is considered to be vulnerable to a rain-induced landslide. Of this percentage, approximately 24% of the residential building stock is of medium vulnerability, 27% of the residential building stock is of high vulnerability, and the remaining 12% is of very high vulnerability to a rain-induced landslide event. None of the commercial building inventory is of medium high or very high vulnerability rating to a rain-induced landslide event.

The tables below show potential dollar exposure to earthquake hazard on St. Thomas, St. Croix and St. John.

TABLE 4.49 ***Estimated Rain-Induced Landslide Exposure and Vulnerability (St. Thomas)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	50%	5%	33%	22%	13%	27%
No. of Residential	11,682	629	3,834	2,546	1,463	3,211
Value of Residential	$3,213,711,877	$173,052,574	$1,054,598,986	$700,405,281	$402,405,769	$883,249,267
% of Commercial	38%	13%	87%	0	0	0
No. of Commercial	830	109	721	0	0	0
Value of Commercial	$691,860,980	$91,034,339	$600,826,640	$0	$0	$0

TABLE 4.50 ***Estimated Rain-Induced Landslide Exposure and Vulnerability (St. Croix)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	18%	46%	20%	17%	13%	5%
No. of Residential	3959	1,805	790	654	504	207
Value of Residential	$1,043,231,966	475,623,664	208,168,636	172,259,816	132,684,653	54,495,197
% of Commercial	18%	70%	30%	0	0	0
No. of Commercial	150	105	46	0	0	0
Value of Commercial	$259,456,696	180,833,455	78,623,241	0	0	0

TABLE 4.51 ***Estimated Rain-Induced Landslide Exposure and Vulnerability (St. John)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	39%	15%	22%	24%	27%	12%
No. of Residential	876	130	197	206	236	107
Value of Residential	$320,308,317	47,473,212	71,913,125	75,445,644	86,187,058	39,289,278
% of Commercial	37%	41%	59%			
No. of Commercial	30	12	18	0	0	0
Value of Commercial	$125,642,478	50,936,140	74,706,338	0	0	0

Critical Facilities

The tables below highlight the results of the vulnerability assessment of each state-owned or operated facility to the earthquake hazard. Results define the potential exposure to Territorial Facilities and Infrastructure for the island of St. Thomas, St. Croix and St. John.

TABLE 4.52 ***Estimated Rain-Induced Landslide Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Thomas)***

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	5	3	2				12,727,552
Fire Stations	5	3	2				7,792,547
Emergency Response	1	1					6,472,875
Hospital, Clinics, and special needs	5	4	1				95,838,253
Government Buildings	11	10	1				118,417,923
Shelters	5	2	1	1	1		123,556,219
Transportation Infrastructure							
Marine Ports	4	4					26,038,712
Airport	1	1					22,475,260
Utilities							
Electrical Power Generating Plants	1	1					51,172,046
Sewage Treatment Plant	1		1				61,792,356
Water Treatment Plant	1		1				
WAPA Tanks	1	1					
Pumping Station	1		1				

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

TABLE 4.53 ***Estimated Rain-Induced Landslide Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Croix)***

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	6	6					63,719,946
Fire Stations	5	5					9,269,808
Emergency Response	N/A						-
Hospital/ Medical Clinic	3	3					135,990,389
Government Buildings	12	11	1				121,046,648
Shelters/Special Needs	11	11					173,286,506
Transportation Infrastructure							
Marine Ports	5	5					9,922,078
Airport	1	1					57,686,500
Utilities							
Electrical Power Generating Plants	1	1					51,917,850
Sewage Pumps	14	14					110,067,300
Wastewater Treatment Plant	1	1					
Water Treatment Plant	1	1					
Water Pumps	8	5	3				

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

TABLE 4.54 ***Estimated Rain-Induced Landslide Exposure and Vulnerability, Critical Facilities and Infrastructure (St. John)***

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	2	1	1				4,321,296
Fire Stations	2	1	1				4,845,666
Emergency Response	1	1					5,142,339
Hospital/ Medical Clinic	2	1	1				17,590,586
Government Buildings	3	2	1				13,159,486
Shelters/Special Needs	5	3	2				52,473,202
Transportation Infrastructure							-
Marine Ports	1	1					2,884,325
Airport	N/A						--
Utilities							-
Electrical Power Generating Plants	1	1					15,575,355
WAPA Desalinization Plant	1	1					
WAPA Water Tank	1	1					
Sewage Treatment Plant	1	1					
Potable Water Tank	1	1					33,518,154

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

4.6.7 TSUNAMI

This section discusses the population and the proportion and value of buildings located in areas affected by a tsunami hazard. It also provides an estimate of proportion of assets located in tsunami hazard areas.

Social Impacts

Table 4.55 shows an estimate of the affected population and area (in square kilometers) as indicators of the social vulnerability of each island. Two special needs population segments are broken out by hazard areas: the number of people less than 18 years of age and the number of people over 65 years of age.

TABLE 4.55 ***Social Impacts (Tsunami)***

Island Jurisdiction	Total Population	Less than 18 Years of Age in Hazard Area	% Less than 18 Years of Age in Hazard Area	Over 65 Years of Age in Hazard Area	% Over 65 Years of Age in Hazard Area
St. Thomas	54,229	2,440	5%	813	2%
St. Croix	56,404	2,758	5%	919	2%
St. John	4,447	141	3%	71	2%

Physical and Economic Impacts

In this Plan Update, economic vulnerability relates to the extent of dollar exposure of its buildings. The findings of the vulnerability assessment for this Plan Update indicate that there was an increase of 1,476 residential properties exposed to this hazard on St. Thomas. For St. Croix there were 1011 less residential properties exposed to this hazard, while on St. John the total number of residential properties exposed decreased by 111. On St. Thomas there were 253 more commercial properties exposed to this hazard. On St. Croix, there were 17 more commercial properties, while on St. John there was an increase of 4 commercial properties exposed to this hazard.

- All building types are equally vulnerable to a tsunami. No regular building structure can be built to withstand a tsunami, as it would not be economically or realistically feasible to do so, given the rare and random nature of this hazard. Of all buildings exposed to this hazard, approximately 40% of the residential building stock is of high vulnerability and the remaining 60% is of very high vulnerability to a tsunami event. The commercial buildings 20% are of high vulnerability and 80% fall in the very high category.

- Tsunamis can devastate development along coastlines, causing widespread property damage and loss of life. Both residential and commercial structures are considered to be equally vulnerable to the tsunami hazard. Tsunamis can cause significant loss of life, especially in low-lying harbors of Charlotte Amalie, Christiansted and Frederiksted.

- Tsunamis have the potential to have an enormous impact of the tourist industry. Cruise ships and their passengers are particularly exposed to this hazard, especially while in harbor.

The tables below show potential dollar exposure to earthquake hazard on St. Thomas, St. Croix and St. John.

TABLE 4.56 ***Estimated Tsunami Exposure and Vulnerability (St. Thomas)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	18%	0	0	0	40%	60%
No. of Residential	4,206	0	0	0	1,682	2,523
Value of Residential	$1,156,936,276	$0	$0	$0	$462,774,510	$694,161,765
% of Commercial	33%	0	0	0	20%	80%
No. of Commercial	721	0	0	0	144	577
Value of Commercial	$ 600,826,640	$ 0 -	$ 0 -	$ 0 -	$ 120,165,328	$ 480,661,312

TABLE 4.57 ***Estimated Tsunami Exposure and Vulnerability (St. Croix)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	11%	0	0	0	40%	60%
No. of Residential	2,510	0	0	0	1,004	1,506
Value of Residential	661,293,152	0	0	0	264,517,261	396,775,891
% of Commercial	5%	0	0	0	20%	80%
No. of Commercial	41	0	0	0	8	33
Value of Commercial	70,485,736	0	0	0	14,097,147	56,388,589

TABLE 4.58 ***Estimated Tsunami Exposure and Vulnerability (St. John)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	13%	0	0	0	40%	60%
No. of Residential	286	0	0	0	114	171
Value of Residential	104,469,790	0	0	0	41,787,916	62,681,874
% of Commercial	13%	0	0	0	20%	80%
No. of Commercial	10	0	0	0	2	8
Value of Commercial	43,193,847	0	0	0	8,638,769	34,555,077

Critical Facilities

Tables 4.59 through 4.61 highlights the results of the vulnerability assessment of each state-owned or operated facility to the Tsunami hazard. Results define the potential exposure to Territorial Facilities and Infrastructure for the island of St. Thomas, St. Croix and St. John.

TABLE 4.59 ***Estimated Tsunami Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Thomas)***

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	5	4				1	12,727,552
Fire Stations	5	3				2	7,792,547
Emergency Response	1	1					6,472,875
Hospital, Clinics, and special needs	5	4				1	95,838,253
Government Buildings	11	4				7	118,417,923
Shelters	5	5					123,556,219
Transportation Infrastructure							
Marine Ports	4	1				3	26,038,712
Airport	1	1					22,475,260
Utilities							
Electrical Power Plant	1					1	51,172,046
Sewage Treatment Plant	1		1				61,792,356
Water Treatment Plant	1		1				
WAPA Tanks	1		1				
Pumping Station	1		1				

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

<u>TABLE 4.60</u> *Estimated Tsunami Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Croix)*

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	6	6					63,719,946
Fire Stations	5	5					9,269,808
Emergency Response	1	1					-
Hospital/ Medical Clinic	3	2				1	135,990,389
Government Buildings	12	11				1	121,046,648
Shelters/Special Needs	11	11					173,286,506
Transportation Infrastructure							
Marine Ports	5	1				4	9,922,078
Airport	1					1	57,686,500
Utilities							
Electrical Power Plant	1	1					51,917,850
Sewage Pumps	14	14					110,067,300
Wastewater Treatment Plant	1					1	
Water Treatment Plant	1	1					
Water Pumps	8	7					

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

TABLE 4.61 ***Estimated Tsunami Exposure and Vulnerability, Critical Facilities and Infrastructure (St. John)***

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	2	1				1	4,321,296
Fire Stations	2	1				1	4,845,666
Emergency Response	1	1					5,142,339
Hospital/ Medical Clinic	2	2					17,590,586
Government Buildings	3	3					13,159,486
Shelters/Special Needs	5	1				1	52,473,202
Transportation Infrastructure							-
Marine Ports	1					1	2,884,325
Airport	N/A						
Utilities							-
Electrical Power Plant	1					1	15,575,355
WAPA Desalinization Plant	1					1	
WAPA Water Tank	1					1	
Sewage Treatment Plant	1	1					
Potable Water Tank	1	1					
							33,518,154

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

4.6.8 WILDFIRE

This section discusses the population and the proportion and value of buildings located in areas affected by a rain-induced landslides. It also provides an estimate of proportion of assets located in areas that are susceptible to rain-induced landslides

Social Impacts

Table 4.62 shows an estimate of the affected population and area (in square kilometers) as indicators of the social vulnerability of each island. Two special needs population segments are broken out by hazard areas: the number of people less than 18 years of age and the number of people over 65 years of age.

TABLE 4.62 ***Social Impacts (Wildfire)***

Island Jurisdiction	Total Population	Less than 18 Years of Age in Hazard Area	% Less than 18 Years of Age in Hazard Area	Over 65 Years of Age in Hazard Area	% Over 65 Years of Age in Hazard Area
St. Thomas	54,229	7,767	14%	1,913	3.53%
St. Croix	56,404	7,111	13%	1,752	3.11%
St. John	4,447	421	9%	104	2.33%

Physical and Economic Impacts

In this Plan Update, economic vulnerability relates to the extent of dollar exposure of its buildings that are susceptible to this hazard. The findings of the vulnerability assessment for this Plan Update indicate that there are 10,067 residential structures and 219 commercial structures exposed to this hazard on St. Thomas. On St. Croix, there are 10,067 residential structures and 575 commercial structures exposed to this hazard on St. Thomas. On St. John, there are 831 residential structures and 35 commercial structures exposed to this hazard.

- On St. Thomas approximately 42% percent of the residential building stock and 35% of the commercial building stock is considered to be vulnerable wildfires. Of this percentage, approximately 32% of the residential building stock is of high vulnerability and the remaining 11% is of very high vulnerability to wildfires. Commercial structures are considered to be less vulnerable to wildfires with the majority of structures falling into the very low and low susceptibility categories.

- On St. Croix approximately 47% percent of the residential building stock susceptible to wildfire hazards. Of this percentage, approximately 26% of the residential building stock is of medium vulnerability, 30% of the residential building stock is of high vulnerability, and the remaining 16% is of very high vulnerability to wildfires. None of the commercial building inventory falls into the medium, high or very high vulnerability hazard rating for a rain-induced landslide.

- On St. John approximately 38% percent of the residential building stock and 44% of the commercial building stock is considered to be vulnerable to a wildfire. Of this percentage, approximately 18% of the residential building stock is of medium vulnerability, 30% of the residential building stock is of high vulnerability, and the remaining 8% is of very high vulnerability to wildfire hazard. None of the commercial building inventory is of medium high or very high vulnerability rating to a rain-induced landslide event.

The tables below show potential dollar exposure to earthquake hazard on St. Thomas, St. Croix and St. John.

TABLE 4.63 ***Estimated Wildfire Exposure and Vulnerability (St. Thomas)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	42%	18%	17%	22%	32%	11%
No. of Residential	9813	1781	1694	2178	3099	1061
Value of Residential	$2,699,517,976	$489,938,678	$466,103,823	$599,108,197	$852,463,874	$291,903,404
% of Commercial	35%	51%	49%	0	0	0
No. of Commercial	774	398	376	0	0	0
Value of Commercial	$644,801,763	$331,612,335	$313,189,428	$0	$0	$0

TABLE 4.64 ***Estimated Wildfire Exposure and Vulnerability (St. Croix)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	47%	10%	17%	26%	30%	16%
No. of Residential	10067	1,051	176	46	14	2
Value of Residential	$2,723,994,577	284,286,019	47,720,282	12,397,796	3,762,452	618,913
% of Commercial	27%	37%	63%	0	0	0
No. of Commercial	590	219	138	0	0	0
Value of Commercial	$389,185,044	144,142,609	90,756,458	0	0	0

TABLE 4.65 ***Estimated Wildfire Exposure and Vulnerability (St. John)***

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	38%	26%	18%	18%	30%	8%
No. of Residential	854	223	154	153	259	65
Value of Residential	$312,095,283	81,626,575	56,353,525	55,923,345	94,585,735	23,606,104
% of Commercial	44%	59%	41%	0	0	0
No. of Commercial	36	21	15	0	0	0
Value of Commercial	$150,128,802	88,712,474	61,416,328	0	0	0

Critical Facilities

The tables below highlight the results of the vulnerability assessment of each state-owned or operated facility to the earthquake hazard. Results define the potential exposure to Territorial Facilities and Infrastructure for the island of St. Thomas, St. Croix and St. John.

TABLE 4.66 *Estimated Wildfire Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Thomas)*

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	5	1			4		12,727,552
Fire Stations	5	1		2	4		7,792,547
Emergency Response	1	1					6,472,875
Hospital, Clinics, and special needs	5	4	1		1		95,838,253
Government Buildings	11	1		1	10		118,417,923
Shelters	5	4		3	1		123,556,219
Transportation Infrastructure							
Marine Ports	4				4		26,038,712
Airport	1				1		22,475,260
Utilities							
Electrical Power Generating Plants	1	1					51,172,046
Sewage Treatment Plant	1		1				61,792,356
Water Treatment Plant	1		1				
WAPA Tanks	1	1					
Pumping Station	1		1				

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

TABLE 4.67 ***Estimated Wildfire Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Croix)***

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	6	3		2	1		63,719,946
Fire Stations	5	1				4	9,269,808
Emergency Response	N/A						-
Hospital/ Medical Clinic	3	2		1		1	135,990,389
Government Buildings	12	7				5	121,046,648
Shelters/Special Needs	11	11		3	8		173,286,506
Transportation Infrastructure							
Marine Ports	5	5					9,922,078
Airport	1	1					57,686,500
Utilities							
Electrical Power Generating Plants	1	1					51,917,850
Sewage Pumps	14	9		3	2	3	110,067,300
Wastewater Treatment Plant	1	1				1	
Water Treatment Plant	1	1					
Water Pumps	8	3		3	2	3	

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

TABLE 4.68 ***Estimated Wildfire Exposure and Vulnerability, Critical Facilities and Infrastructure (St. John)***

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	2				2		4,321,296
Fire Stations	2	1			1		4,845,666
Emergency Response	1	1					5,142,339
Hospital/ Medical Clinic	2	1					17,590,586
Government Buildings	3				3		13,159,486
Shelters/Special Needs	5	3			2		52,473,202
Transportation Infrastructure							-
Marine Ports	1	1					2,884,325
Airport	N/A						
Utilities							-
Electrical Power Generating Plants	1					1	15,575,355
WAPA Desalinization Plant	1					1	
WAPA Water Tank	1					1	
Sewage Treatment Plant	1					1	
Potable Water Tank	1					1	33,518,154

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility.

4.7 LOSS ESTIMATES

This section of the Plan Update presents the "estimate of losses," including: exposure, damage, and loss estimates analyzed on a hazard-by-hazard basis. The findings support local and regional planners' understanding of the potential impacts of each hazard and enable a comparison of hazards by quantifying potential exposures impacts.

The loss estimates provided in this section were developed using available data, and the methodologies applied have resulted in an approximation of risk. These estimates should be used to understand relative risk from hazards and potential losses.

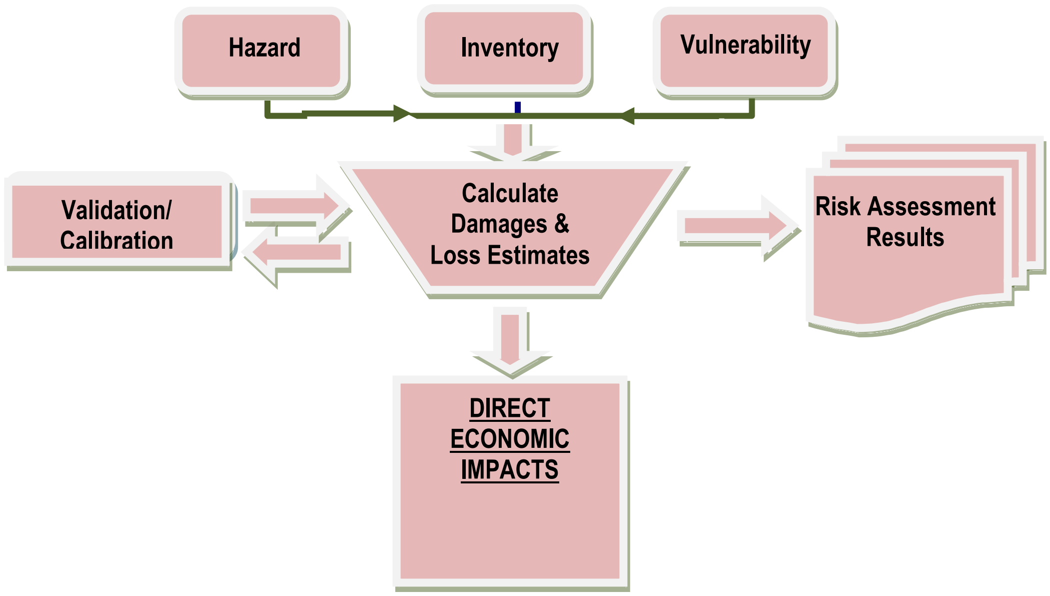
However, it is important to understand that uncertainties are inherent in any loss estimation methodology, arising in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from approximations and simplifications that are necessary for a comprehensive analysis.

The risk assessment utilized for this Plan Update was parametric. The risk analyses are based on a comprehensive methodology that incorporates approaches for:

- Characterizing Hazards, understanding the nature of the hazards (i.e. level of ground shaking, wind speed, depth of flooding);
- Categorization of the built environment, understanding number, distribution, and value of assets (i.e. general buildings & critical facilities),
- Vulnerability Analysis, understanding the damage and loss characteristics of identified buildings, and
- Estimating damage and losses to buildings and critical facilities.

Figure 4.26 illustrates a conceptual model of the loss estimation methodology as applied for the US Virgin Islands Mitigation Plan.

FIGURE 4.26 ***Conceptual Model of Risk Assessment Methodology***



For each of the hazards (Earthquake, Riverine Flooding, Coastal Flooding, Hurricane Winds, and Tsunami) estimates were derived from calculating the number of buildings exposed to the hazard and the potential economic losses. The economic loss ratio is also provided, which is the percentage of the losses against the total value of all the structures within the Territory for a particular hazard.

Loss estimates associated with drought were not analyzed using a risk assessment methodology based on the same principals as described above. Instead, available historical data for each hazard are used and statistical evaluations are performed using manual calculations. The general steps used in this methodology are summarized below:

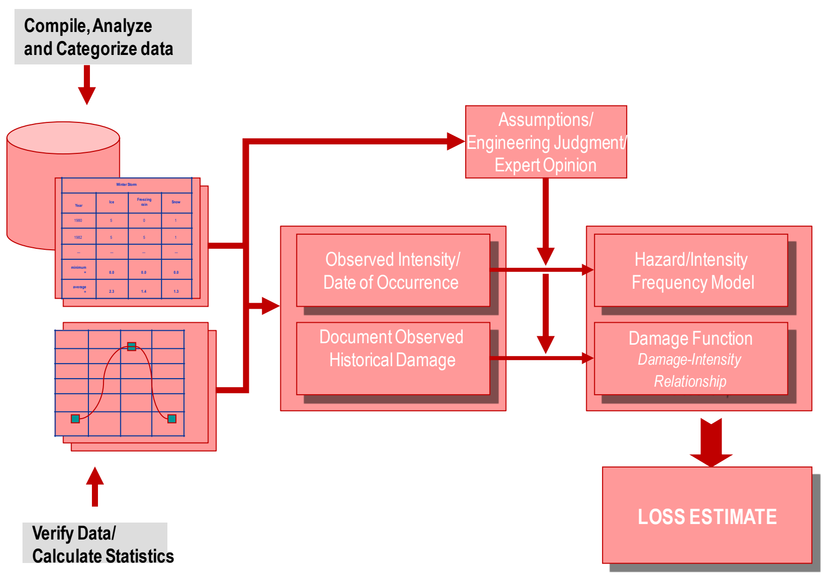
- Compile and analyze available data from national and local sources
- Verify data and conduct statistical analysis to relate historical patterns within the data to existing hazard models
- Develop model parameters based on data analysis, existing hazard models, and risk engineering judgment

The paucity of historic information that was available for these hazards necessitated the CIPA consultant team to try to ascertain the following:

- Analysis of frequency of hazard occurrence
- Analysis of intensity and/or damages parameters associated with hazard occurrence (for example, one drought event = $ in estimated damages)
- Development of frequency curves expected damages
- Estimate losses

Figure 4.27 illustrates a conceptual model of the statistical risk assessment methodology as applied to the US Virgin Islands.

FIGURE 4.27: ***Conceptual Model of Statistical Risk Assessment Methodology***



The risk assessment methodologies used in the Plan Update are standardized, meaning they have been applied to each island in the same way. Impacts presented in this study include only direct social economic losses because of data limitations and time constraints on the project; however these results represent the key impacts faced by US Virgin Islands.

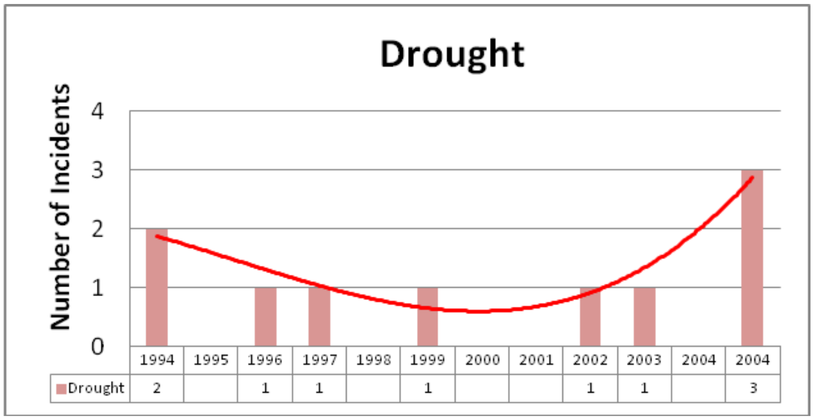
4.7.1 DROUGHT

This subsection of the risk assessment presents the “estimate of losses for drought hazard.

Estimated Losses: Economic Impact

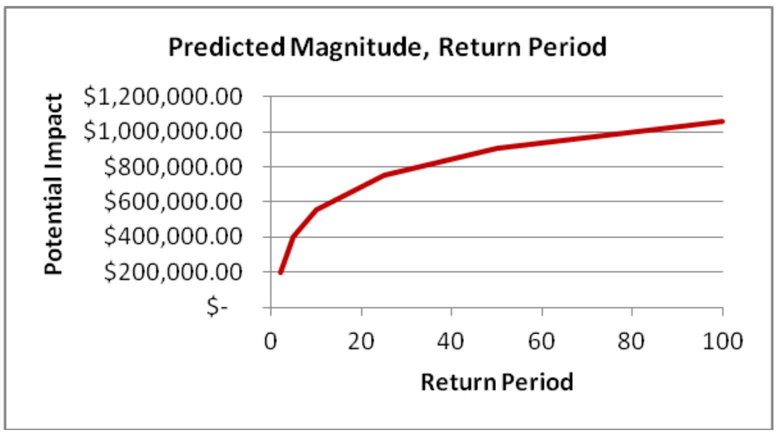
Estimated losses for drought were aggregated for primary economic impacts that could impact the US Virgin Islands through regional economic loss. The primary economic impact was assumed to be increased costs associated with feeding cattle.

FIGURE 4.28 ***Historical Droughts in US Virgin Islands, 2003-2007***



This figure was based regional historic drought data for Puerto Rico and the US Virgin Islands. Based on the available data and the assumptions provided above, the predicted impact of a drought with a 50% probability of occurrence is $200,000.

FIGURE 4.29 ***Historical Droughts in US Virgin Islands, 2003-2007***



The expected impact of a drought for a 100 year return period is approximately 1.058M. Damage parameters from only two (2) historic events in the US Virgin Islands were used to develop this estimate.

4.7.2 EARTHQUAKE

This subsection of the risk assessment presents the “estimate of losses,” including: exposure, damage, and loss estimates analyzed for the earthquake hazard.

Estimated Losses: General Building Stock

Damages and losses were estimated based on a 1000-year probabilistic ground shaking scenario. Property damage is summarized by general occupancy classes. The total damage for a 1000-year event was estimated to be $6 billion for St. Thomas, $4.3 billion for St. Croix and $463 million for St. John. This represents a $419 billion increase in estimated losses for on St. Thomas since the 2011 Plan. Estimated losses for St. Croix have increased by 11M and 9.7 M on St. John.

TABLE 4.69 ***Estimated Losses: General Building Stock for Earthquake Hazard***

Occupancy	No of Affected Buildings	Expected Losses	% Value
St. Thomas			
Residential	21,679	$ 4,641,269,145	72%
Commercial	981	$ 1,384,710,463	86%
Total	22,660	$ 6,025,979,608	
St. Croix			
Residential	18,082	$ 3,645,930,917	56%
Commercial	670	$ 746,489,600	53%
Total	18,753	$ 4,392,420,517	
St. John			
Residential	1,431	$ 386,386,207	0.54
Commercial	70	$ 76,830,370	0.65
Total	1,501	$ 463,216,578	

Estimated Losses: Critical Facilities and Infrastructure

Critical facilities and infrastructure losses for St. Thomas, St. Croix and St. John are highlighted in Table 4.70.

TABLE 4.70 ***Estimated Losses: Critical Facilities and Infrastructure for Earthquake Hazard***

Facility	St. Thomas	St. Croix	St. John
Critical Facilities			
Police Stations	$13,804,002	$42,949,130	$2,373,142
Fire Stations	$32,370,825	$7,431,814	$3,321,795
Emergency Response	$6,331,171	$2,476,394	$3,367,056
Hospital/ Medical Clinic	$71,272,393	$106,217,486	$9,393,598
Government Buildings	$103,612,740	$109,157,907	$8,777,514
Shelters/Special Needs	$123,062,681	$128,181,063	$54,803,795
Transportation Infrastructure			
Marine Ports	$6,844,012	$364,105	$33,953
Airport	$26,632	$30,627,988	$0
Utilities			
Electrical Power Generating Plants	$30,892,492	$43,768,184	$14,094,331
Water Treatment Plants	$44,509,147	$15,989,798	$2,096,480
Wastewater Treatment Plants	$910,804	$16,707,348	$20,768,378
Pumps	$295,361	$16,476,882	--
Tanks	$8,080,947	$8,451,850	$1,090,889

Detailed information on critical facilities identified to be high risk structures is included in Appendix E. These are defined as those expected to sustain damages exceeding 60% for any of the hazards considered.

4.7.3 RIVERINE FLOODING

This subsection of the risk assessment presents the "estimate of losses," including: exposure, damage, and loss estimates analyzed for the riverine flooding hazard.

Estimated Losses: General Building Stock

Property damage due to the riverine hazard is summarized in Table 4.71 by occupancy class. The total expected loss for a 100-year MRP is approximately $1B million for St. Thomas, $768 million for St. Croix and $17million for St. John. This represents a significant increase for the Territory.

TABLE 4.71 ***Estimated Losses: General Building Stock for Riverine Flooding Hazard***

Occupancy	No of Affected Buildings	Expected Losses	% Value
St. Thomas			
Residential	11,390	$ 752,430,862	0.12
Commercial	742	$ 292,639,745	0.18
Total	12,133	$ 1,045,070,607	
St. Croix			
Residential	4,648	$ 618,081,641	0.09
Commercial	349	$ 150,076,139	0.11
Total	4,996	$ 768,157,780	
St. John			
Residential	309	$ 15,718,980	0.02
Commercial	9	$ 1,570,220	0.01
Total	318	$ 17,289,200	

The estimated loss values are based on the count of buildings damaged as presented in the table above. Building counts are based on a geographic distribution of structures by occupancy class across estate boundaries.

Estimated Losses: Critical Facilities and Infrastructure

Critical facilities and infrastructure losses for St. Thomas, St. Croix and St. John are highlighted in Table 4.72.

TABLE 4.72 ***Estimated Losses: Critical Facilities and Infrastructure for Riverine Flooding Hazard***

Facility	St. Thomas	St. Croix	St. John
Critical Facilities			
Police Stations	$2,208,247	$846,102	$2,450,885
Fire Stations	$32,635,564	$0	$0
Emergency Response	$0	$0	$0
Hospital/ Medical Clinic	$4,495,220	$0	$0
Government Buildings	$81,303,611	$41,134,403	$6,613,182
Shelters/Special Needs	$55,258,961	$8,146,920	$24,107,203
Transportation Infrastructure	$0	$0	$0
Marine Ports	$2,143,620	$0	$34,183
Airport	$0	$0	$0
Utilities	$0	$0	$0
Electrical Power Generating Plants	$0	$0	$2,768,783
Water Treatment Plants	$44,437,250	$9,229,275	$0
Wastewater Treatment Plants	$937,800	$0	$22,218,625
Pumps	$0	$1,525,473	--
Tanks	$0	$517,334	$0

Detailed information on critical facilities identified to be high risk structures is included in Appendix E. These are defined as those expected to sustain damages exceeding 60% for any of the hazards considered.

4.7.4 Coastal Flooding

This subsection of the risk assessment presents the "estimate of losses," including: exposure, damage, and loss estimates analyzed for the coastal flooding hazard.

Estimated Losses: General Building Stock

The total estimated property damages and losses for a Category 5 Storm Surge event is $171 million for St. Thomas, $78.5 million for St. Croix and $26.6 million for St. John. Table 4.48 presents these results by occupancy class. This represents a $439 million increase in estimated losses for the Territory since the 2011 Plan.

TABLE 4.73 ***Estimated Losses: General Building Stock for Coastal Flooding Hazard***

Occupancy	No of Affected Buildings	Expected Losses	% Value
St. Thomas			
Residential	1,511	$ 115,105,946	0.02
Commercial	236	$ 56,606,106	0.04
Total	1,747	$ 171,712,053	
St. Croix			
Residential	3,425	$ 52,319,194	0.01
Commercial	334	$ 26,256,719	0.02
Total	3,760	$ 78,575,913	
St. John			
Residential	386	$ 22,500,497	0.03
Commercial	3	$ 4,123,048	0.03
Total	389	$ 26,623,544	

The estimated loss values are based on the count of buildings damaged as presented in the table above. Building counts are based on a geographic distribution of structures by occupancy class across estate boundaries.

Estimated Losses: Critical Facilities and Infrastructure

Critical facilities and infrastructure losses for St. Thomas, St. Croix and St. John are highlighted in Table 4.74.

TABLE 4.74 ***Estimated Losses: Critical Facilities and Infrastructure For Coastal Flooding Hazard***

Facility	St. Thomas	St. Croix	St. John
Critical Facilities			
Police Stations	$133,178	$0	$0
Fire Stations	$13,900,517	$0	$0
Emergency Response	$0	$0	$0
Hospital/ Medical Clinic	$3,196,231	$0	$0
Government Buildings	$6,455,387	$3,987,047	$9,113,250
Shelters/Special Needs	$0	$0	$0
Transportation Infrastructure	$0	$0	$0
Marine Ports	$2,774,553	$2,871,330	$102,548
Airport	$0	$0	$0
Utilities	$0	$0	$0
Electrical Power Generating Plants	$13,317,856	$0	$14,766,840
Water Treatment Plants	$0	$9,844,560	$0
Wastewater Treatment Plants	$17,091,250	$0	$29,055,125
Pumps	$0	$379,623	--
Tanks	$0	$162,591	$1,296,013

Detailed information on critical facilities identified to be high risk structures is included in Appendix E. These are defined as those expected to sustain damages exceeding 60% for any of the hazards considered.

4.7.5 HURRICANE WIND

This subsection of the risk assessment presents the "estimate of losses," including: exposure, damage, and loss estimates analyzed for the hurricane wind hazard.

Estimated Losses: General Building Stock

Property damage due to the wind-hurricane hazard is summarized in Table 4.73 by occupancy class. The total expected for a loss for a hurricane event with a 50 year MRP is approximately $3.6 billion for St. Thomas, $1.8 billion for St. Croix and $190 million for St. John. This represents an increase of $2.3 billion in the Territory since the 2011 Plan.

TABLE 4.75 ***Estimated Losses: General Building Stock for Hurricane Wind Hazard***

Occupancy	No of Affected Buildings	Expected Losses	% Value
St. Thomas			
Residential	14,184	$ 3,097,521,815	0.48
Commercial	856	$ 571,109,732	0.36
Total	15,041	$ 3,668,631,547	
St. Croix			
Residential	12,986	$ 1,508,195,711	0.23
Commercial	555	$ 307,082,553	0.22
Total	13,542	$ 1,815,278,264	
St. John			
Residential	745	$ 163,596,725	0.23
Commercial	32	$ 26,457,092	0.22
Total	777	$ 190,053,817	

Because of differences in building construction, residential structures are more susceptible to wind damage. In using the damage counts for buildings, the number of buildings impacted should be interpreted loosely. Damage to a specific building can range from slight damage to total destruction; the total dollar damage estimates the overall impact to individual buildings at an aggregate level. The increase in construction cost, both commercial and residential, have increased the value of the building stock and thus estimated losses.

Estimated Losses: Critical Facilities and Infrastructure

Critical facilities and infrastructure losses for St. Thomas, St. Croix and St. John are highlighted in Table 4.76.

TABLE 4.76 ***Estimated Losses: Critical Facilities and Infrastructure for Hurricane Wind Hazard***

Facility	St. Thomas	St. Croix	St. John
Critical Facilities			
Police Stations	$8,455,970	$28,488,869	$1,783,516
Fire Stations	$30,035,180	$6,495,932	$2,481,830
Emergency Response	$3,402,979	$1,462,893	$1,899,208
Hospital/ Medical Clinic	$50,949,906	$94,355,181	$8,595,732
Government Buildings	$84,600,149	$80,955,418	$5,960,850
Shelters/Special Needs	$83,389,427	$102,857,136	$41,504,841
Transportation Infrastructure	$0	$0	$0
Marine Ports	$10,007,260	$750,907	$90,909
Airport	$9,924,923	$28,222,427	n/a
Utilities	$0	$0	$0
Electrical Power Generating Plants	$10,839,286	$23,936,125	$5,266,686
Water Treatment Plants	$19,565,950	$23,936,125	$1,287,957
Wastewater Treatment Plants	$364,269	$9,267,130	$9,494,825
Pumps	$110,851	$6,865,235	--
Tanks	$2,998,359	$2,084,234	$591,014

Detailed information on critical facilities identified to be high risk structures is included in Appendix E. These are defined as those expected to sustain damages exceeding 60% for any of the hazards considered.

4.7.6 RAIN-INDUCED LANDSLIDE

A deterministic approach was used to address the rain induced landslide hazard based on a worst-case scenario that assumed extensive to complete damage of structures during a landslide event.

Probability was not assigned to the rain-induced landslide hazard. Limited data and time needed to perform detailed mapping and statistical analysis go well beyond the scope of this study effort. The primary economic impact was assumed to be costs associated with infrastructure repair.

Based on the available data and the assumptions provided above, estimated impact of a rain-induced landslide is approximately $500,000. Damage parameters from historic events in the US Virgin Islands were used to develop this estimate.

Estimated Losses: General Building Stock

The physical damage that could occur as a result of rain-induced landslide is summarized in Table 4.77. Estimated property damages and losses for the landslide hazard were aggregated across occupancy classes and are estimated to be $76 million for St. Thomas, $20 million for St. Croix and $21 million for St. John.

TABLE 4.77 ***Estimated Losses: General Building Stock for Rain-Induced landslide Hazard***

Occupancy	No of Affected Buildings	Expected Losses	% Value
St. Thomas			
Residential	4,169	76,647,667	0.01
Commercial	0	$ -	0.00
Total	4,169	$ 76,647,667	
St. Croix			
Residential	1,209	$ 20,892,953	0.004
Commercial	0	$ -	0.00
Total	1,328	$ 20,892,953	
St. John			
Residential	455	$ 21,247,859	0.03
Commercial	0	$ -	0.00
Total	535	$ 21,247,859	

Estimated Losses: Critical Facilities and Infrastructure

Critical facilities and infrastructure losses for St. Thomas, St. Croix and St. John are highlighted in Table 4.78.

TABLE 4.78 ***Estimated Losses: Critical Facilities and Infrastructure for Rain-induced Landslide Hazard***

Facility	St. Thomas	St. Croix	St. John
Critical Facilities			
Police Stations	$0	$0	$0
Fire Stations	$0	$0	$0
Emergency Response	$0	$0	$0
Hospital/ Medical Clinic	$2,260,000	$0	$0
Government Buildings	$0	$0	$0
Shelters/Special Needs	$20,893,076	$0	$0
Transportation Infrastructure			
Marine Ports	$0	$0	$0
Airport	$0	$0	$0
Utilities			
Electrical Power Generating Plants	$0	$0	$0
Water Treatment Plants	$0	$0	$0
Wastewater Treatment Plants	$0	$0	$0
Pumps	$0	$0	--
Tanks	$0	$0	$0

4.7.7 TSUNAMI

Estimated Losses: General Building Stock

A deterministic approach was used to address the tsunami hazard based on a worst-case scenario that assumed extensive to complete damage within the Tsunami inundation area. Probability was not assigned to the tsunami hazard. Limited data and time needed to perform statistical analysis go well beyond the scope of this study effort. Therefore, while total damages were estimated, a return period is not applicable for the Tsunami hazard. The physical damage that could occur as a result of Tsunami is summarized in Table 4.76. Estimated property damages and losses for the tsunami hazard were aggregated across occupancy classes and are estimated to be $1.2 billion for St. Thomas, $786 million for St. Croix and $114 million for St. John. This represents a $234 million increase in estimated losses for on the Territory since the 2011 Plan.

TABLE 4.79 ***Estimated Losses: General Building Stock for Tsunami Hazard***

Hazard	No of Affected Buildings	Expected Losses	% Value
St. Thomas			
Residential	4,417	$ 808,769,974	0.19
Commercial	376	$ 402,633,004	0.38
Total	4,793	$ 1,211,402,978	
St. Croix			
Residential	2,961	$ 524,598,730	0.13
Commercial	258	$ 261,998,197	0.30
Total	3,218	$ 786,596,927	
St. John			
Residential	833	$ 96,449,264	0.19
Commercial	35	$ 18,284,842	0.21
Total	868	$ 114,734,106	

Estimated Losses: Critical Facilities and Infrastructure

Critical facilities and infrastructure losses for St. Thomas, St. Croix and St. John are highlighted in Table 4.80.

TABLE 4.80 ***Estimated Losses: Critical Facilities and Infrastructure for Tsunami Hazard***

Facility	St. Thomas	St. Croix	St. John
Critical Facilities			
Police Stations	$532,714	$0	$1,036,413
Fire Stations	$54,003,910	$0	$1,171,972
Emergency Response	$0	$0	$0
Hospital/ Medical Clinic	$11,762,331	$26,441,762	$0
Government Buildings	$98,704,238	$4,208,549	$15,003,849
Shelters/Special Needs	$0	$0	$13,348,261
Transportation Infrastructure			
Marine Ports	$11,098,214	$8,251,656	$290,551
Airport	$0	$61,528,500	$0
Utilities			
Electrical Power Generating Plants	$49,720,000	$50,850,000	$18,458,550
Water Treatment Plants	$68,365,000	$18,458,550	$3,586,232
Wastewater Treatment Plants	$1,442,768	$27,346,000	$0
Pumps	$0	$663,030	--
Tanks	$0	$258,667	$1,472,742

Detailed information on critical facilities identified to be high risk structures is included in Appendix E. These are defined as those expected to sustain damages exceeding 60% for any of the hazards considered.

4.7.8 WILDFIRE

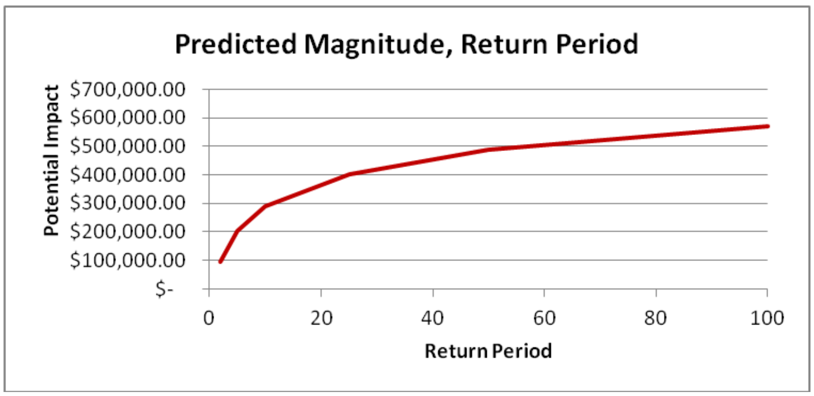
This subsection of the risk assessment presents the "estimate of losses for wildfires. Estimated losses for wildfires were aggregated for primary economic impacts that could impact the US Virgin Islands through economic loss.

Estimated Losses: Economic Impact

Estimated losses for drought were aggregated for primary economic impacts that could impact the US Virgin Islands through regional economic loss. The primary economic impact was assumed to be increased costs associated with feeding cattle.

This figure was based regional historic drought data for the US Virgin Islands. Based on the available data and the assumptions provided above, the predicted impact of a drought with a 50% probability of occurrence is $93,500,000 and a 1% occurrence of experiencing a wildfire event of $570,000.00.

FIGURE 4.29 ***Historical Wildfire in US Virgin Islands, 2000-2010***



The expected impact of a drought for a 100 year return period is approximately 570,000.00. Damage parameters from seventeen (17) events historic events in the US Virgin Islands were used to develop this estimate.

4.8 LOSS ESTIMATION SUMMARY AND HAZARD RANKING

This section of the Plan Update, presents a summary of the loss estimates similar to that included in the 2011 Plan. This section is used to evaluate the risk between hazards facing USVI. To do so, one must understand that the risk from a hazard is relative to its return period. For the purposes of risk assessment, a return period has been selected for each hazard analysis.

To assist in evaluating the results of this study, a simple ranking methodology has been developed based on a comparison of the losses per year (i.e. aggregate losses/ return period) and the expected period of recovery following the hazard events considered for this study. Table 4.81 represents hazards that are a more pressing concern to the territory. This ranking provides information on hazards that the territory should focus on (i.e. hazards that require aggressive correction of deficiencies with community funding). This ranking is based on an expected loss per year for each hazard, simply calculated as the total expected losses (critical facilities, commercial and residential) divided by the Return Period of the selected event, representing the amount of capital the territory would have to set aside to cover the damages for such an event.

TABLE 4.81 ***Hazard-by-Hazard Summary of Loss Estimates for US Virgin Islands***

Hazard	Return Period (Years)	Critical Facility Losses	Residential Losses	Commercial Losses	Total Loss	Loss/Year
St. Thomas						
Drought	100	N/A	N/A	N/A	$ 1,058,989.77	$ 10,590
Earthquake	1000	$ 442,013,206	$ 4,641,269,145	$ 1,384,710,463	$ 6,467,992,814	$ 6,467,993
Riverine Flooding	100	$ 223,420,272	$ 752,430,862	$ 292,639,745	$ 1,268,490,879	$ 12,684,909
Coastal Flooding	120	$ 56,868,971	$ 115,105,946	$ 56,606,106	$ 228,581,024	$ 1,904,842
Hurricane	50	$ 314,644,509	$ 3,097,521,815	$ 571,109,732	$ 3,983,276,056	$ 79,665,521
Rain-Induced Landslide	50	$ 23,153,076	$ 76,647,667	$ -	$ 99,800,743	$ 1,996,015
Tsunami	500	$ 295,629,176	$ 808,769,974	$ 402,633,004	$ 1,507,032,154	$ 3,014,064
Wildfire	10				$ 571,815	$ 57,181
St. Croix						
Drought	100	N/A	N/A	N/A	$ 1,058,989.77	$ 10,590
Earthquake	1000	$ 528,799,950	$ 3,645,930,917	$ 746,489,600	$ 4,921,220,467	$ 4,921,220
Riverine Flooding	100	$ 61,399,508	$ 618,081,641	$ 150,076,139	$ 829,557,287	$ 8,295,573
Coastal Flooding	120	$ 17,245,151	$ 52,319,194	$ 26,256,719	$ 95,821,063	$ 798,509
Hurricane	50	$ 409,677,613	$ 1,508,195,711	$ 307,082,553	$ 2,224,955,877	$ 44,499,118
Rain-Induced Landslide	50	$ -	$ 20,892,953	$ -	$ 20,892,953	$ 417,859
Tsunami	500	$ 198,006,714	$ 524,598,730	$ 261,998,197	$ 984,603,641	$ 1,969,207
Wildfire	10				$ 571,815	$ 57,181
St. John						
Drought	100	N/A	N/A	N/A	$ 1,058,989.77	$ 10,590
Earthquake	1000	$ 120,120,930	$ 444,103,045	$ 88,306,986	$ 652,530,961	$ 652,531
Riverine Flooding	100	$ 58,192,860	$ 18,067,019	$ 1,804,774	$ 78,064,652	$ 780,647
Coastal Flooding	120	$ 54,333,776	$ 25,861,531	$ 4,738,932	$ 84,934,239	$ 707,785
Hurricane	50	$ 78,957,369	$ 188,034,154	$ 30,409,148	$ 297,400,671	$ 5,948,013
Rain-Induced Landslide	50	$ -	$ 21,247,859	$ -	$ 21,247,859	$ 424,957
Tsunami	500	$ 54,368,571	$ 96,449,264	$ 18,284,842	$ 169,102,677	$ 338,205
Wildfire	10				$ 571,815	$ 57,181

This ranking mechanism allows not only a ranking for each hazard, but a weight factor for each hazard to compare the relative economic losses to the community The expected loss per year of Return Period can allow each jurisdiction individually to prioritize their hazards on an individual basis, and also allows the territory as a whole to determine which hazard most affects them as a whole.

The Recovery Ranking Table was not developed for this Plan Update. The paucity of data for certain hazards would lead to inclusive findings and would be misleading to gauge recovery efforts. Instead the potential dollar loss rankings are summarized in Table 4.82. It shows that the dollar loss for the VI as a whole is greatest for hurricanes and wildfires.

TABLE 4.82 ***Summary of Hazard Rankings for USVI***

Hazard	St. Thomas	St. Croix	St. John
Drought	8	8	8
Earthquake	3	3	4
Riverine Flooding	2	2	2
Coastal Flooding	5	5	3
Hurricane	1	1	1
Rain-Induced Landslide	6	6	5
Tsunami	4	4	6
Wildfire	7	7	7

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